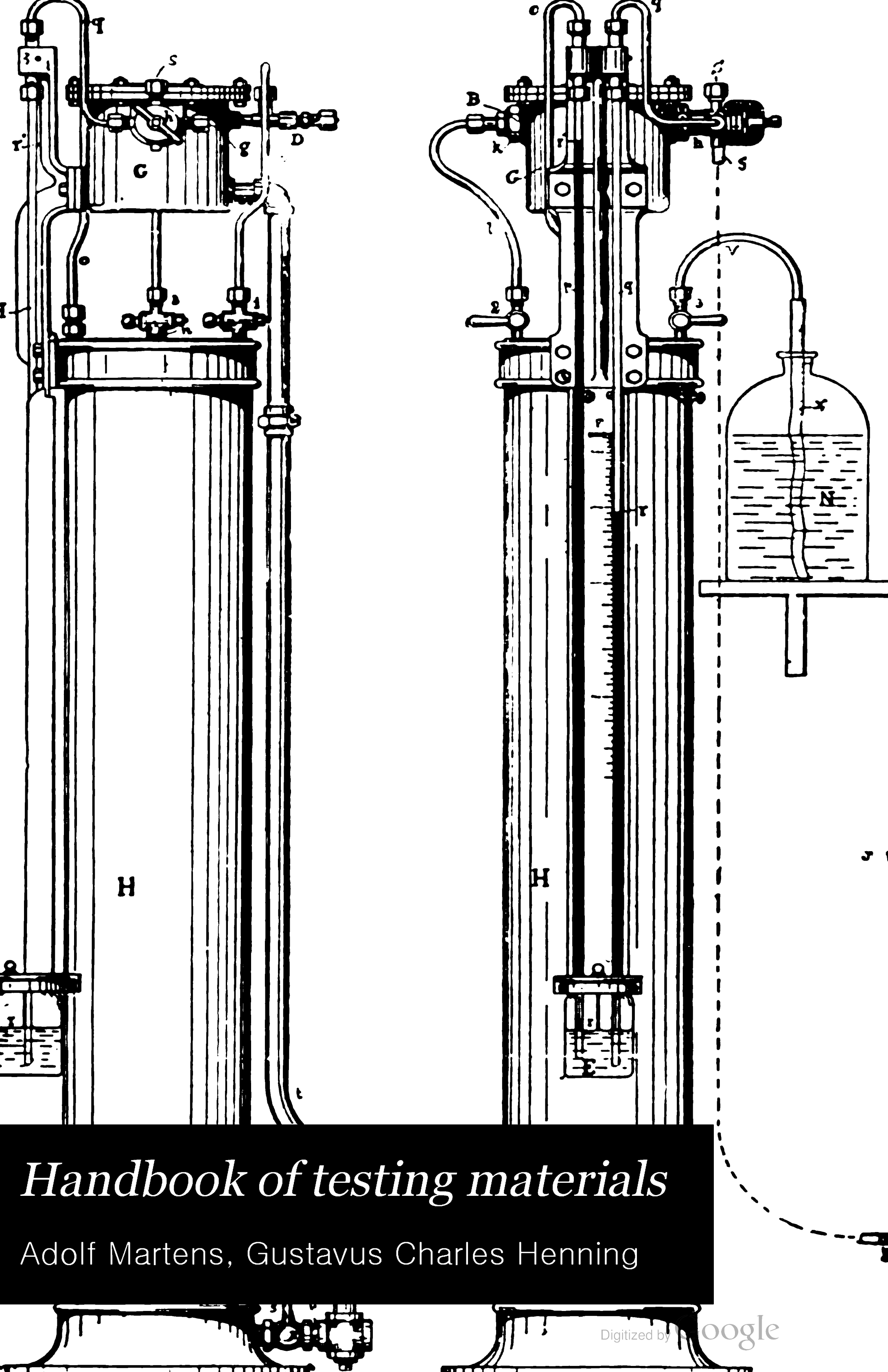


Handbook of testing materials

Adolf Martens, Gustavus Charles Henning

2 vol.

HANDBOOK

OF

TESTING MATERIALS.

FOR THE CONSTRUCTOR.

PART I.

METHODS, MACHINES, AND AUXILIARY APPARATUS.

(IN TWO VOLUMES: VOL. I, TEXT; VOL. II, ILLUSTRATIONS.)

VOL. II. ILLUSTRATIONS.

BY

PROFESSOR ADOLF MARTENS,

Director of the Royal Testing Laboratories at Berlin and at Charlottenburg.

AUTHORIZED TRANSLATION AND ADDITIONS

BY

GUS. C. HENNING, M.E.,

(STEVENS, '76.)

Member of the Council of the American Society of Mechanical Engineers and of the International Association for Testing Materials; Member of the American Institute of Mining Engineers and of the American Society of Naval Engineers; Member of the Institute of Mechanical Engineers and of the Iron and Steel Institute of Great Britain.

FIRST EDITION.

FIRST THOUSAND.

NEW YORK:

JOHN WILEY & SONS.

LONDON: CHAPMAN & HALL, LIMITED.

1899.

ROBERT DRUMMOND, PRINTER, NEW YORK.

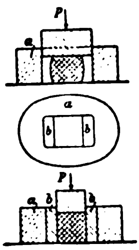


Fig. 1.

(25)

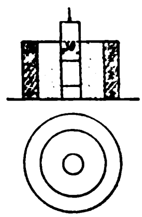


Fig. 2.

(20)

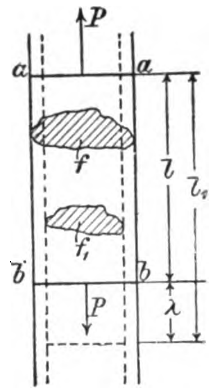


Fig. 3.

(33)

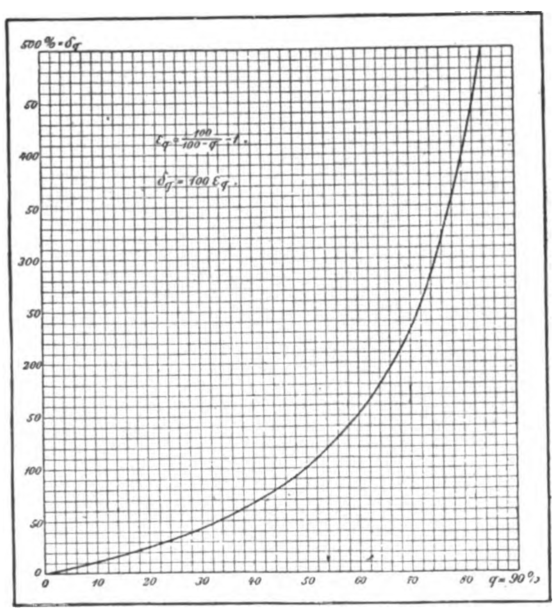


Fig. 4.

(36)

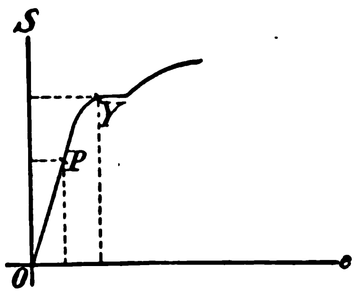


Fig. 5.

(38)

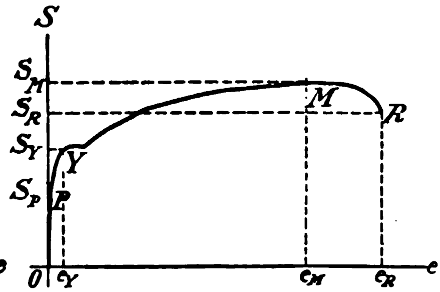


Fig. 6.

(39)

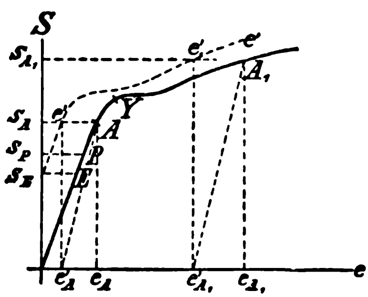


Fig. 7.

(41)

Fig. 8.

(44)

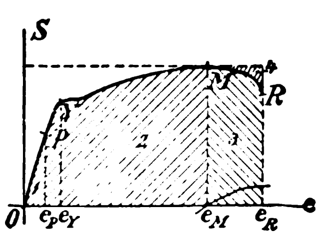


Fig. 9.

(48)

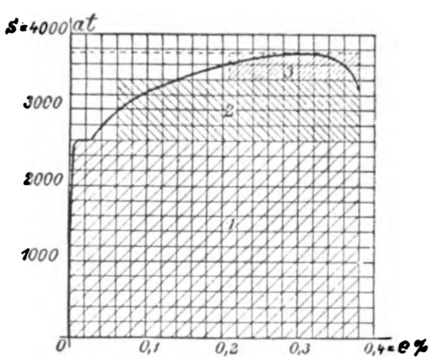


Fig. 10.

(50)

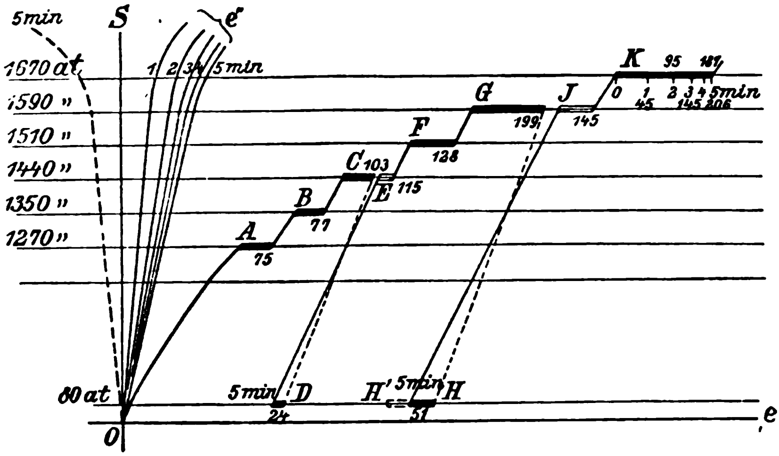


Fig. 11.

(53)

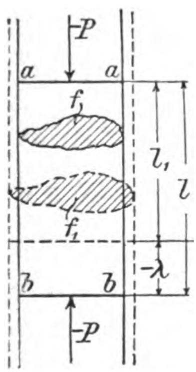


Fig. 12.

(55)

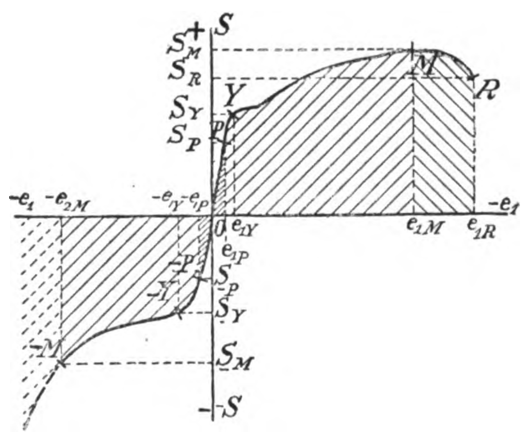


Fig. 13.

(56)

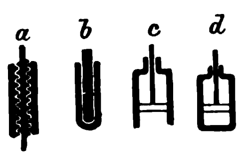


Fig. 14.

(64)

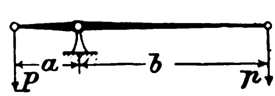


Fig. 15.

(65)

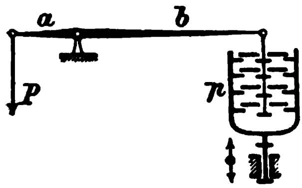


Fig. 16.
(65*b*)

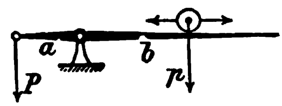


Fig. 17.
(65*b*)

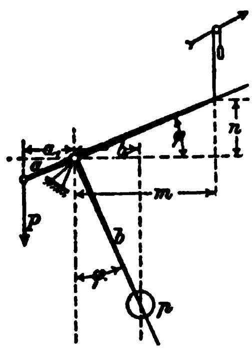


Fig. 18.
(65*d*)

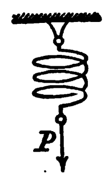


Fig. 19.
(65*e*)

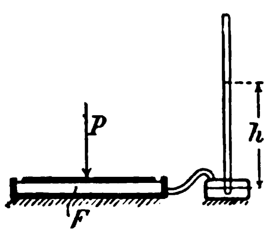


Fig. 20.
(65*f*)

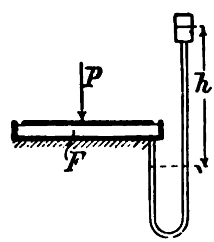


Fig. 21
(65*f*)

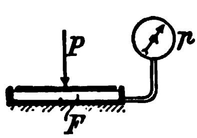


Fig. 22.
(65)

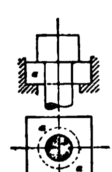


Fig. 23.
(68)

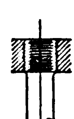


Fig. 24.
(68)

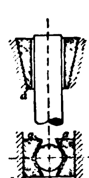


Fig. 25.
(69)

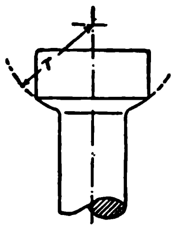


Fig. 26.

(70)

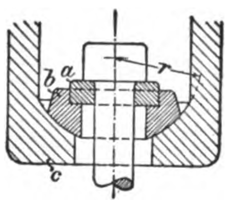


Fig. 27.

(70)

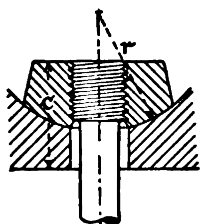


Fig. 28.

(70)

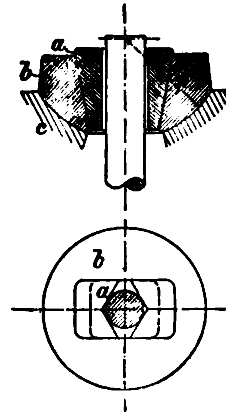


Fig. 29.

(70)

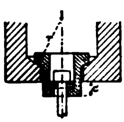


Fig. 30.

(70)

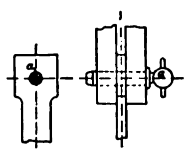


Fig. 31.

(70)

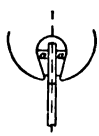


Fig. 32.

(71)

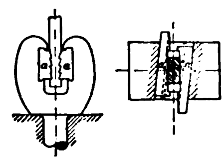


Fig. 33.

(71)

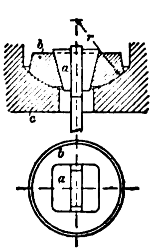


Fig. 34.

(72)

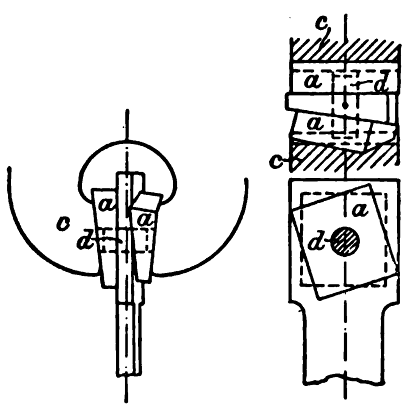


Fig. 35.

(72)

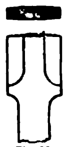


Fig 36.

(72)

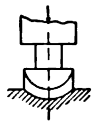


Fig. 37.

(73)

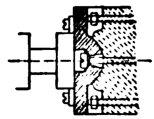


Fig. 38.

(73)

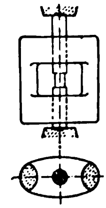


Fig. 39.

(73)

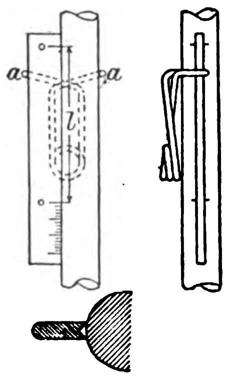


Fig. 40.

(76)

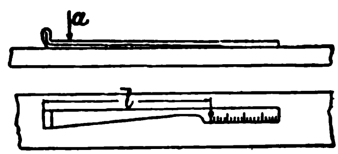


Fig. 41.

(76)

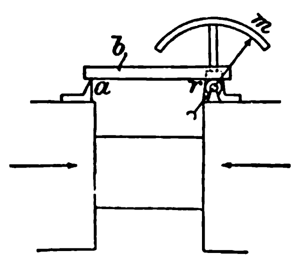


Fig. 42.

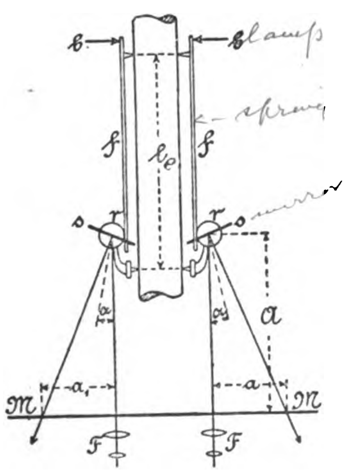


Fig. 44.

(82)

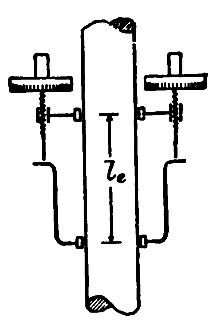


Fig. 43.

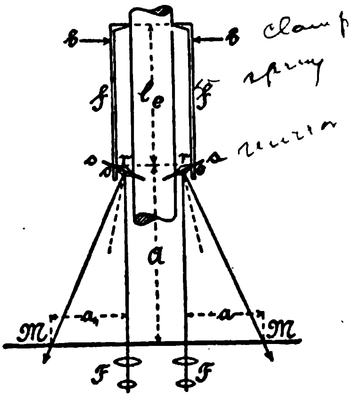


Fig. 46.
88

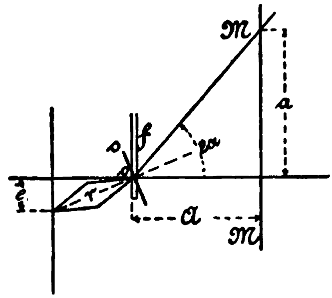


Fig. 47.
88

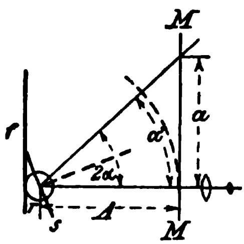


Fig. 45.
(86)

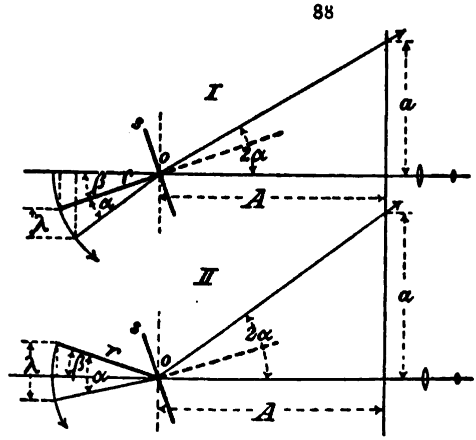


Fig. 48.
(89)

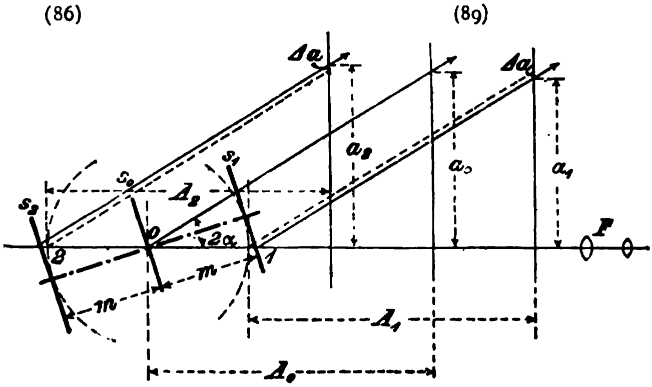


Fig. 49.
(94)

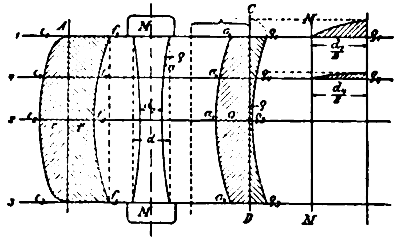


Fig. 51

(101)

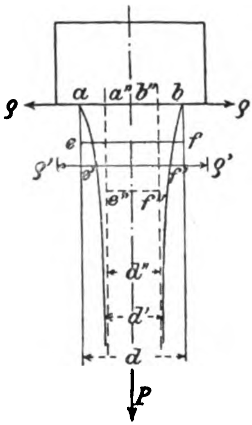


Fig. 50.

(100)

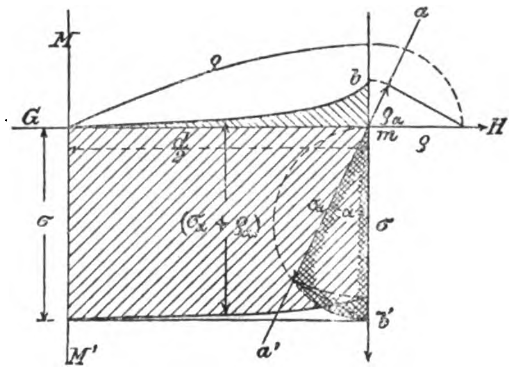


Fig. 52.

(101*a*)

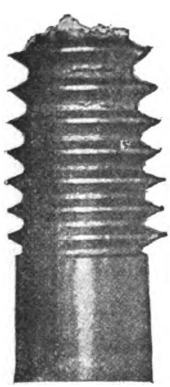


FIG. 53.

(103)

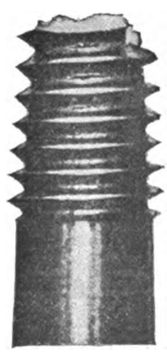


FIG. 54.

(103)

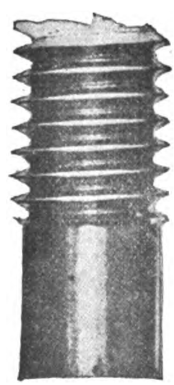


FIG. 55.

(103)

Sharp angle.

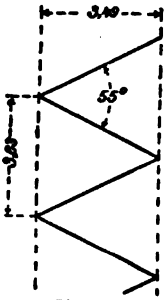


Fig. 56.

(103)

Whitworth.

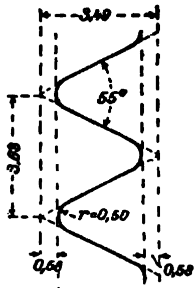


Fig. 57

(103)

U. S. Standard.

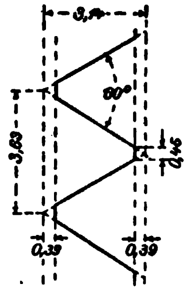


Fig. 58.

(103)

Assoc. Germ. Engrs.

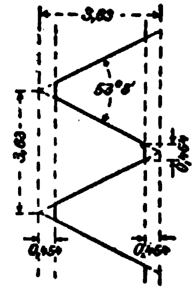


Fig. 59.

(103)

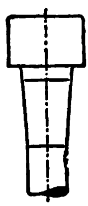


Fig. 60.

(104)

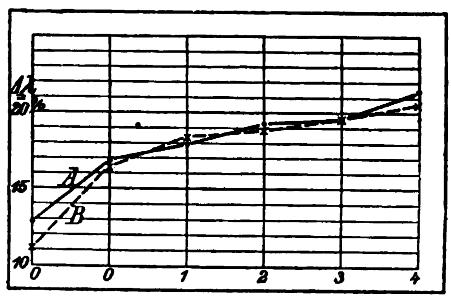


Fig 61.

(104)

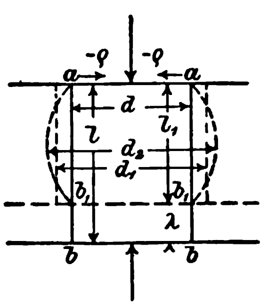


Fig. 62.

(105)

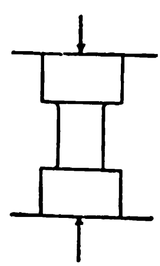


Fig. 63.

(105)

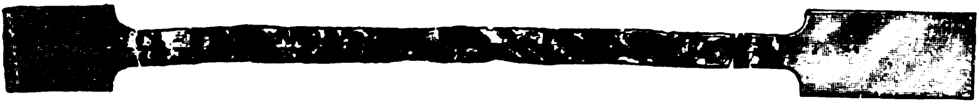


Fig. 64.
(106)

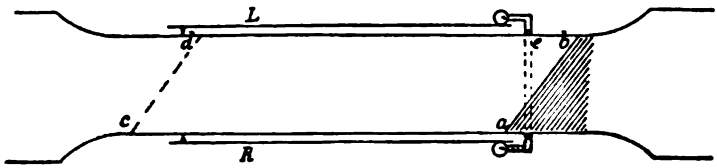


Fig. 65.
(110)

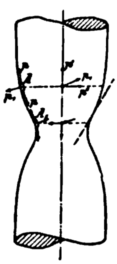


Fig. 66.
(114)

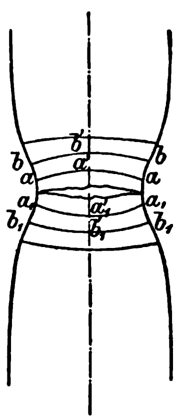


Fig. 67.
(110)

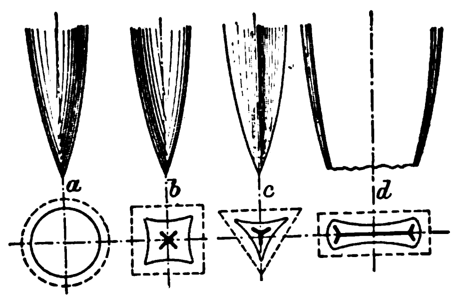


Fig. 68.
(118)

(118)

Fig. 69.

(118)

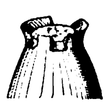


Fig. 70.

(118)

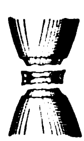


Fig. 71.

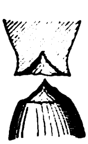


Fig. 72.
(118)

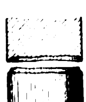


Fig. 73.
(118)

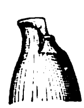


Fig. 74.
(118)

Fig. 75.
(118)

Fig. 76.

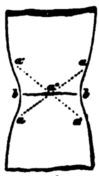


Fig. 77.
(119)

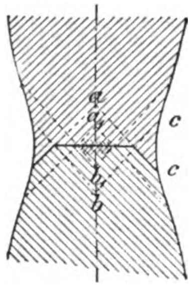


Fig. 78.
(119)

Fig. 79.
(121)

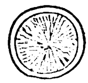


Fig. 80.
(121)

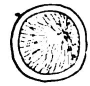


Fig. 81.
(121)

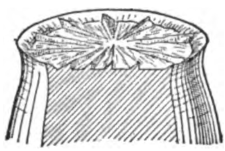


Fig. 82.
(122)

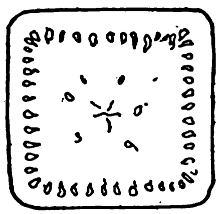


Fig. 83.
(122)

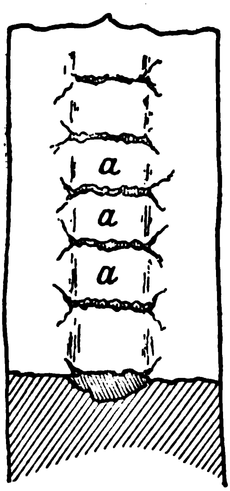


Fig. 84.
(124)

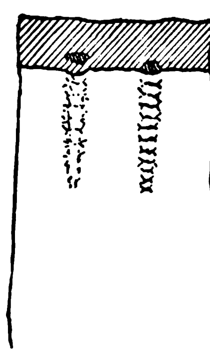


Fig. 84 a.
(124)

(125)

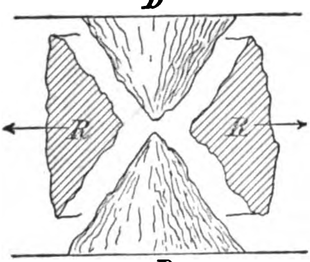


Fig. 85.

(125)

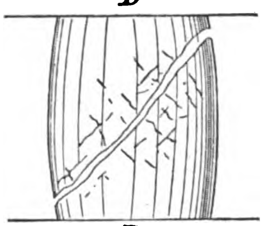


Fig. 86.

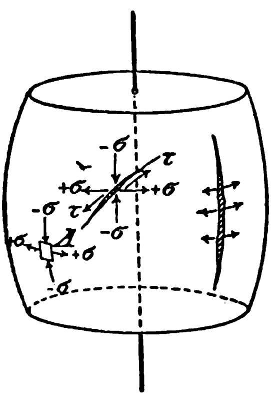


Fig. 87.
(127)

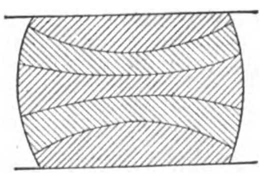


Fig. 88.
(127)

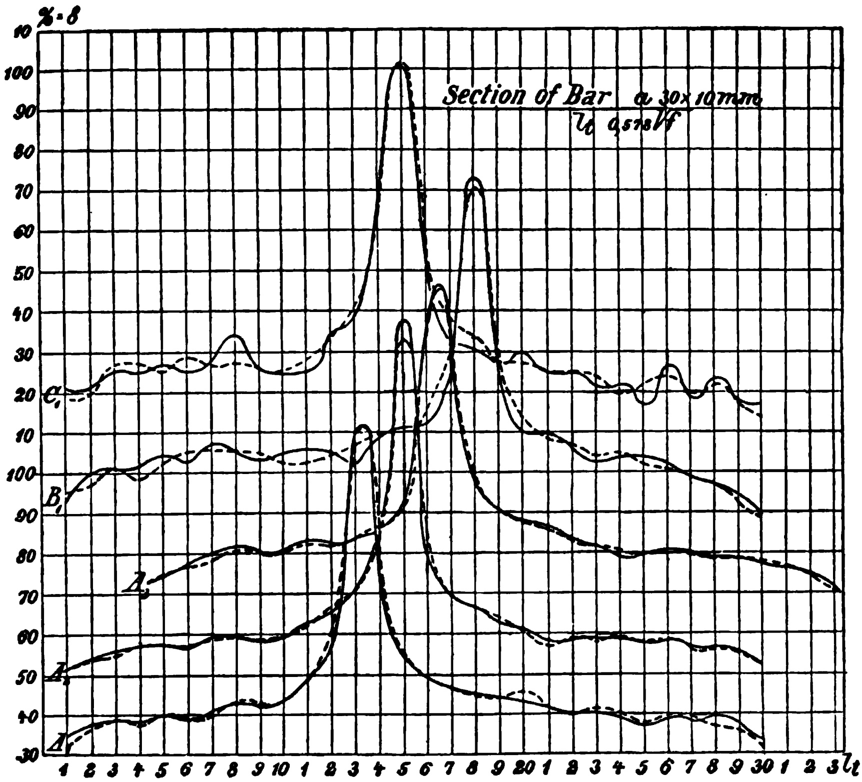


Fig. 89.
(133)

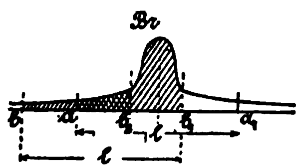


Fig. 90.
(134)

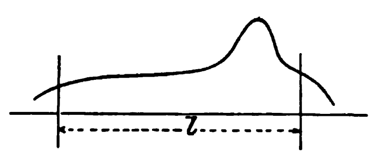


Fig. 91.
(134)

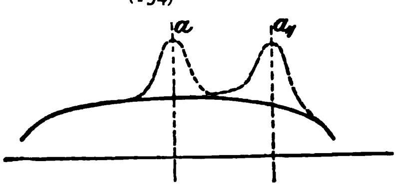


Fig. 92.
(135)

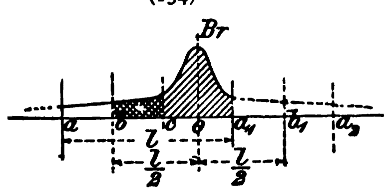


Fig. 93.
(135)

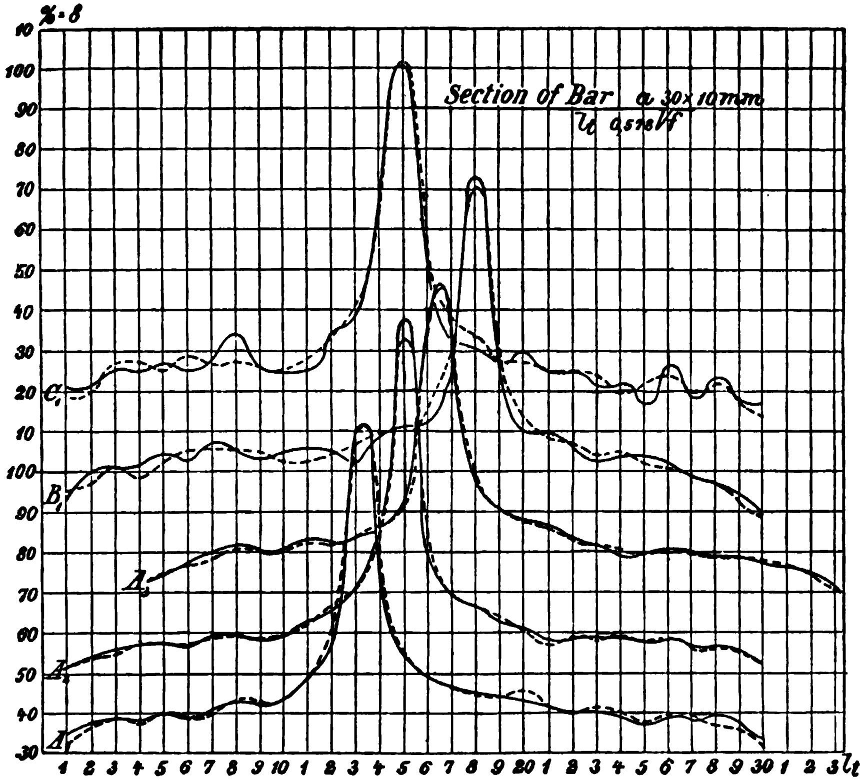


Fig. 89.
(133)

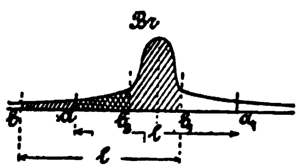


Fig. 90.
(134)

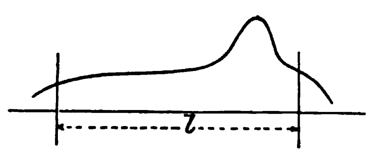


Fig. 91.
(134)

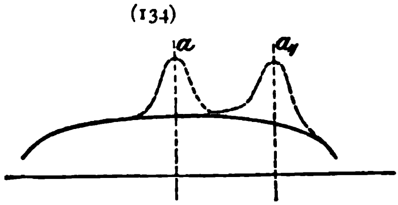


Fig. 92.
(135)

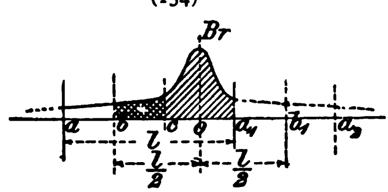


Fig. 93.
(135)

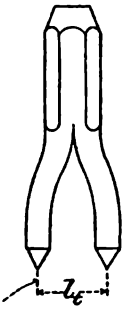


Fig. 94.

(137)

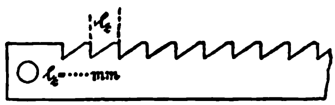


Fig. 95.

(137)

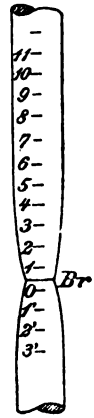


Fig. 96.

(137)

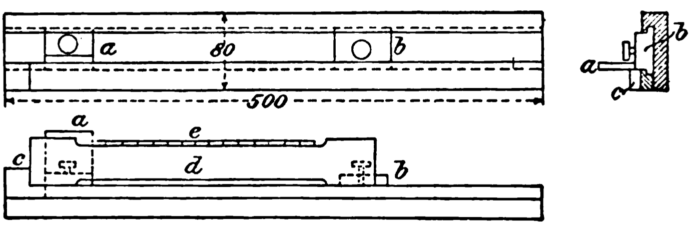


Fig. 98.

(137)

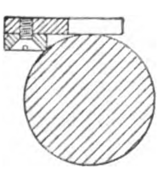


Fig. 97.

(137)

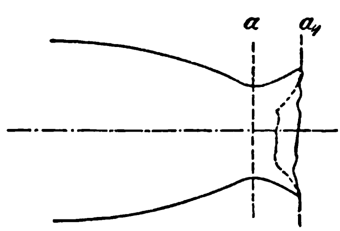


Fig. 99.

(138)

Low Steel (Flusseisen). Effect of Shape on Extensibility.

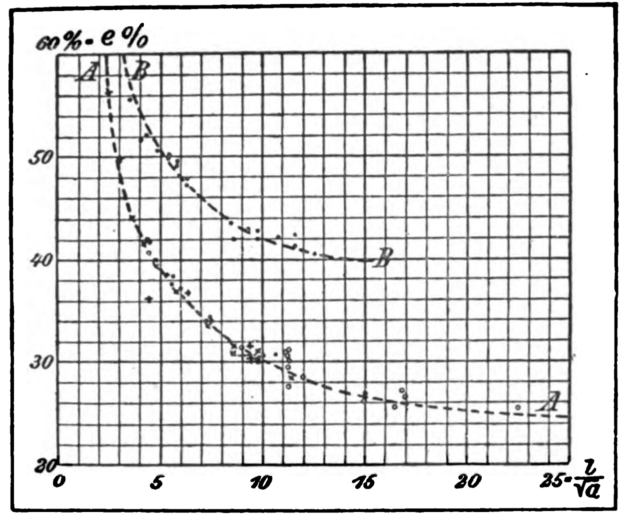


Fig. 100.

(148)

Group A: ● Flat bars of uniform thickness and $\frac{w}{t}$ = 2.5; 1.2; 1.8; 1.4.
× " " " " width " " = 3.0; 2.1; 1.7; 1.3.
+ " " " similar area " " = 1.7.
o Rounds of (2.5; 2.0; 1.5; 1.0 cm) diam. = 1"; 0.8"; 0.6"; 0.4" diam.

Group B: (Curve shifted 10% vertically).
● Flat bars with mill-scale; other material.

Low Steel (Flusseisen). Effect of Shape on Extensibility.

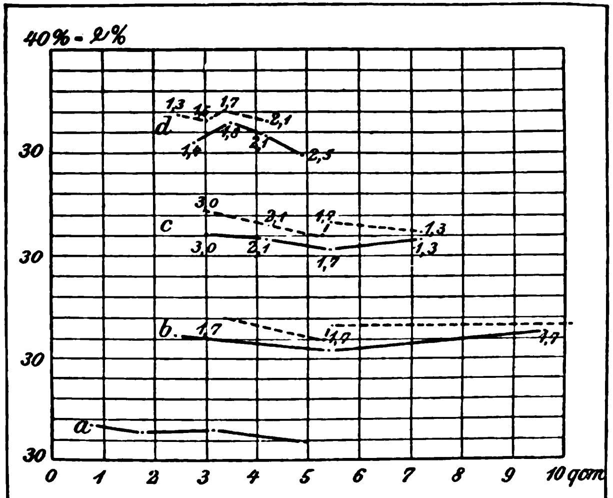


Fig. 101.

(149)

Extensibility e% determined on bars of varying size and shape of section, but of ratio $l / \sqrt{a} = 8.5$

Full lines: Finished bars.
Broken lines: Bars with mill-scale (other material).
Group *a*: Rounds 1.0 to 2.5 cm diam.
b: Flat bars of similar section $\frac{w}{t} = 1.7$.
c: " " " equal width " = 3.0 to 1.5.
d: " " " " thickness " = 2.5 to 1.3

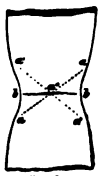


Fig. 77.
(119)

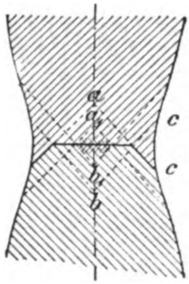


Fig. 78.
(119)

Fig. 79.
(121)

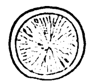


Fig. 80.
(121)

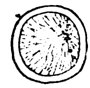


Fig. 81.
(121)

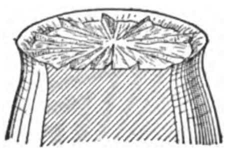


Fig. 82.
(122)

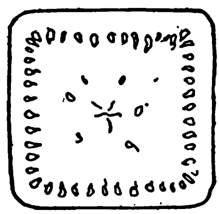


Fig. 83.
(122)

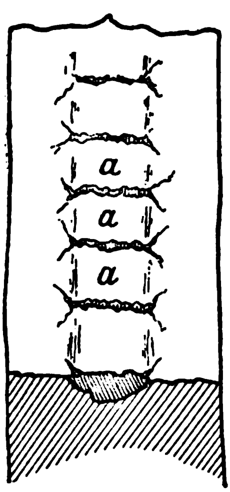


Fig. 84.
(124)

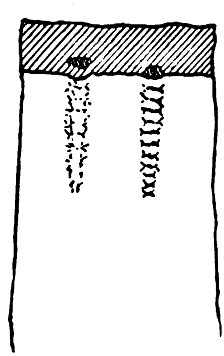


Fig. 84a.
(124)

(125)

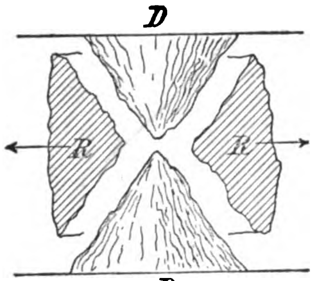


Fig. 85.

(125)

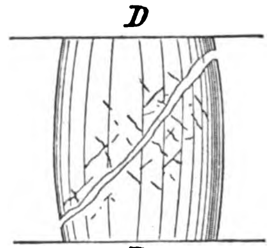


Fig. 86.

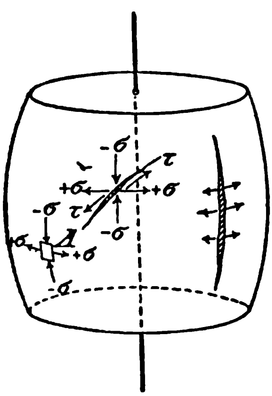


Fig. 87.

(127)

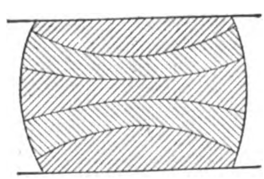


Fig. 88.

(127)

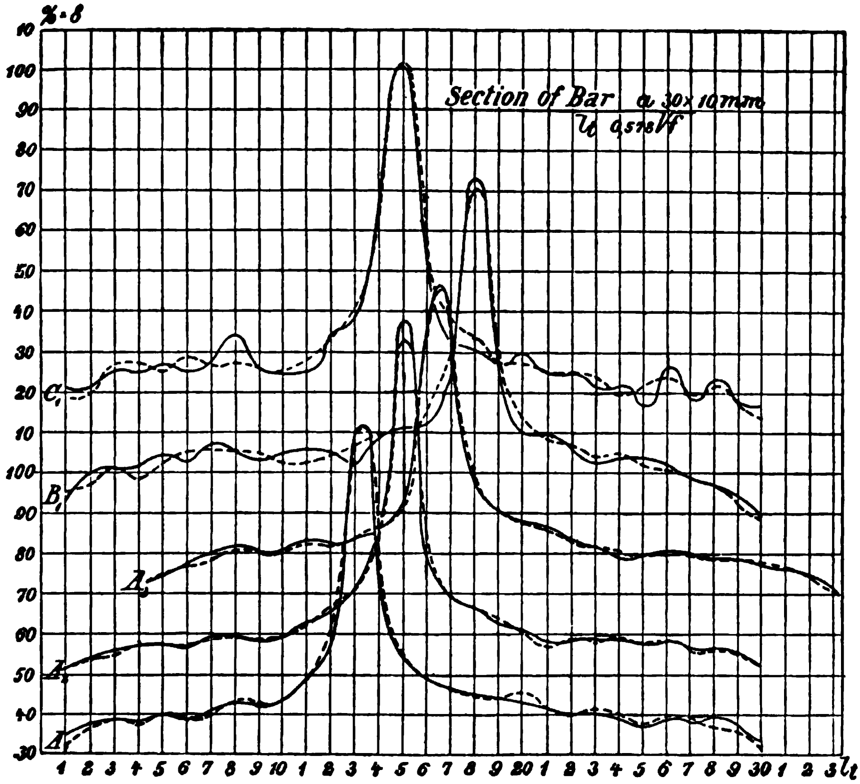


Fig. 89.
(133)

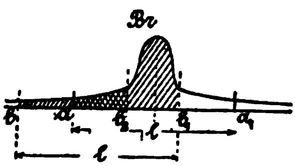


Fig. 90.
(134)

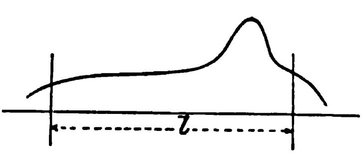


Fig. 91.
(134)

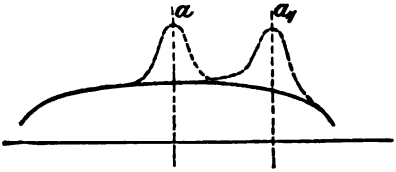


Fig. 92.
(135)

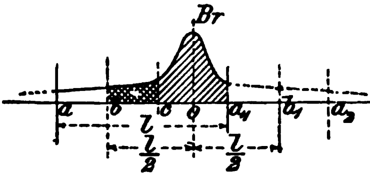


Fig. 93.
(135)

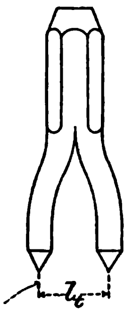


Fig. 94.

(137)

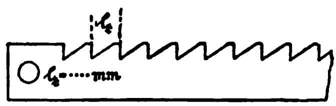


Fig. 95.

(137)

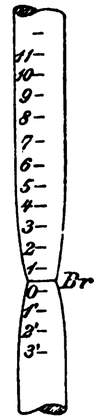


Fig. 96.

(137)

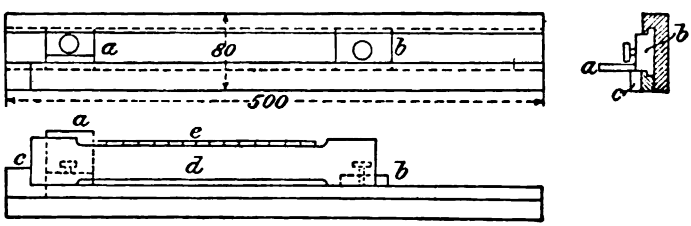


Fig. 98.

(137)

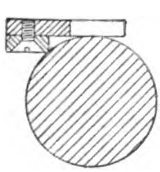


Fig. 97.

(137)

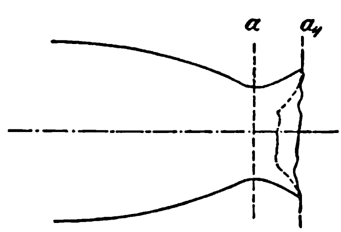


Fig. 99.

(138)

Low Steel (Flusseisen). Effect of Shape on Extensibility.

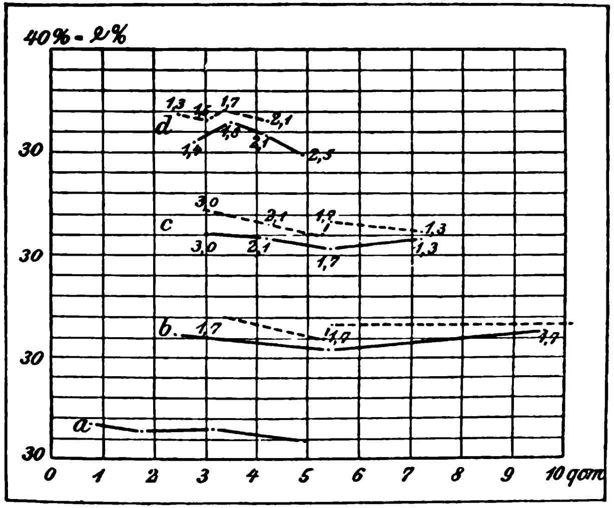


Fig. 101.

(149)

Extensibility e% determined on bars of varying size and shape of section, but of ratio $l / \sqrt{a} = 8.5$

Full lines: Finished bars.

Broken lines: Bars with mill-scale (other material).

Group *a*: Rounds 1.0 to 2.5 cm diam.

b: Flat bars of similar section $\frac{w}{t} = 1.7$.

c: " " " equal width " = 3.0 to 1.5.

d: " " " " thickness " = 2.5 to 1.3

Low Steel (Flusseisen). Effect of Shape on Extensibility.

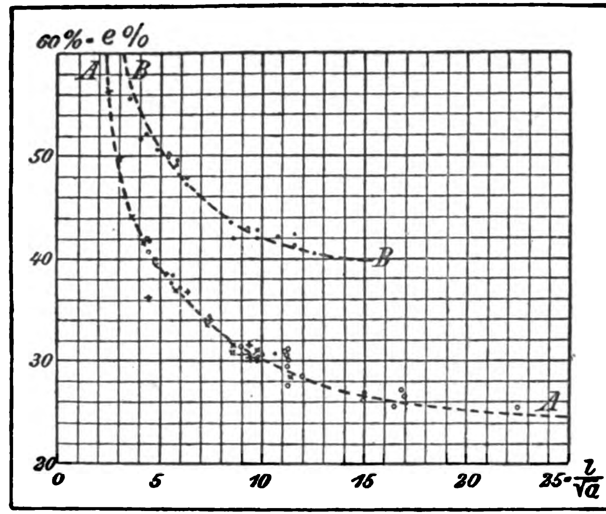


Fig. 100.

(148)

Group A: • Flat bars of uniform thickness and $\frac{w}{t}$ = 2.5; 1.2; 1.8; 1.4.

× " " " " width " " = 3.0; 2.1; 1.7; 1.3.

+ " " " similar area " " = 1.7.

o Rounds of (2.5; 2.0; 1.5; 1.0 cm) diam. = 1"; 0.8"; 0.6"; 0.4" diam.

Group B: (Curve shifted 10% vertically).

• Flat bars with mill-scale; other material.

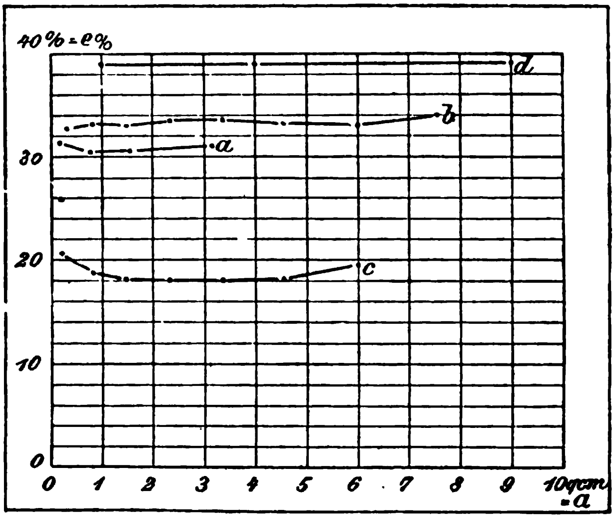


Fig. 102.

(150)

Low Steel (Flussiesen). Effect of Shape on Extensibility.

Lines a-c = Rounds.

a) Steel ($S_Y = 36{,}500$; $S_M = 60{,}000$) of diams. 0.2″; 0.4″; 0.8″ $l_g = 11.2\sqrt{a}$;

b) " ($S_Y = 35{,}250$; $S_M = 60{,}700$) " " 0.276″; 1.22″ } $l_g = 8.2\sqrt{a}$.

c) " ($S_Y = 54{,}400$; $S_M = 93{,}500$) " " " ; " }

Line d : Flat bars.

d) Steel ($S_Y = 26{,}800$; $S_M = 60{,}000$) $\frac{w}{l} = 4$; $l_g = 5\sqrt{a}$.

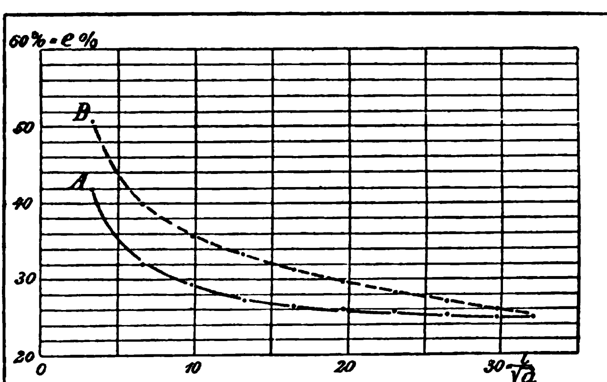


Fig. 103.

(150)

Low Steel (Flusseisen). Effect of Heads on Extensibility (Barba).

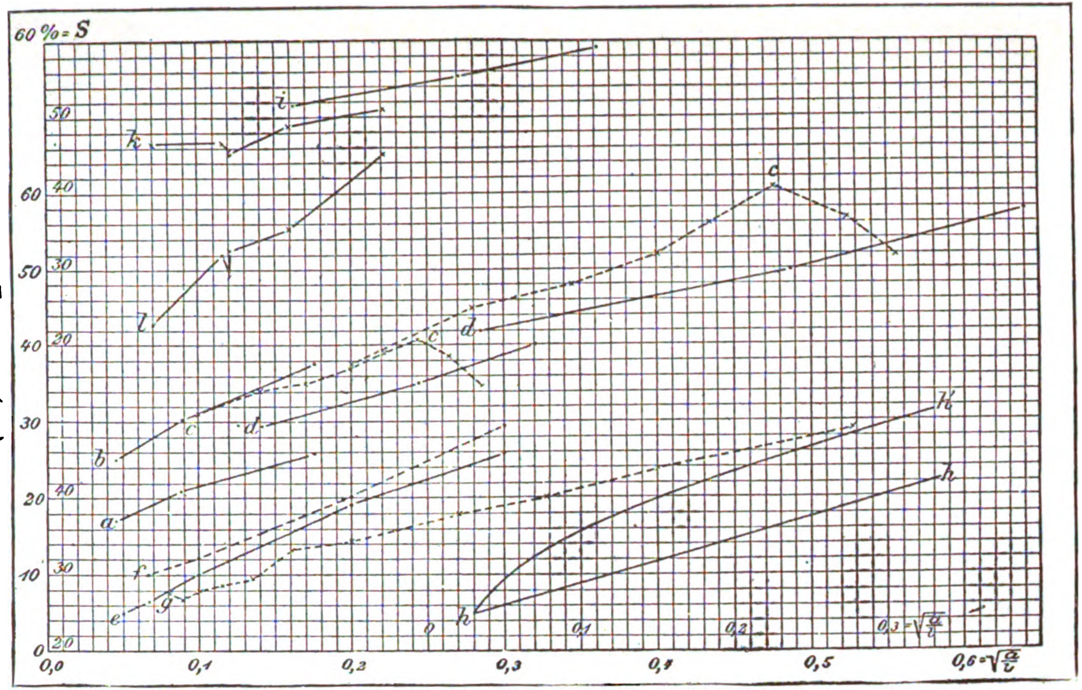


FIG. 104. (150)

Effect of Shape of Bar and Ratio $\frac{1}{n} = \sqrt{\frac{a}{g}}$ on Extensibility.

Lines *a–h*: Low Steel (Flusseisen).

a) Barba: $S_Y = 49{,}500$; $S_M = 87{,}600$; $l = 4$ in. rounds: $d = 0.2''$; $0.4''$ and $0.8''$.

b) " " $= 36{,}700$; " $= 54{,}700$; $l =$ " " " " = " ; " " "

c) " " $= 36{,}400$; " $= 5?{,}900$; $l = 2$ in. and $4''$ flat bars; $\frac{w}{t} = 1$ to 8.

d) " " $= 30{,}700$; " $= 60{,}900$; $l = 4$ in. " " " $= 2$ to 10.

e and *f*) Bauschinger:

g) Hackney:

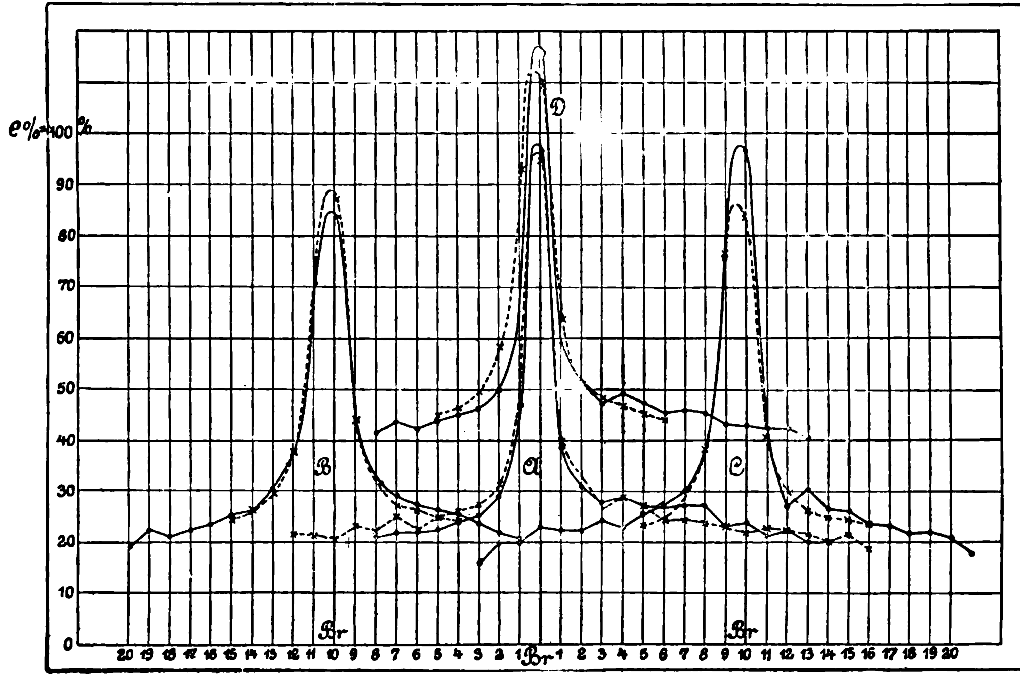
h) Barba (derived from Fig. 101):

Lines *i–l* of Copper.

i) Barba: $S_Y = 12{,}200$; $S_M = 34{,}700$; $l_g = 4$ in. flat bars $\frac{w}{t} = 2$ to 10.

k) Martens: " $= 10{,}000$; " $= 33{,}700$ } flat bars $\frac{w}{t}$ 1 to 5.

l) " " $= 21{,}000$; " $= 34{,}800$ }



Curves of Elongation of Geometrically Similar Bars.

Group A: Full line: rough rounds 0.8 in. diam.; $l_d = 0.4$ in.
Dotted line: finished rounds 0.51 in. diam.; $l_d = 02.55$ in.
" B: Full line: flat bars finished on edges only, $a = 1.6 \times 0.51$ in.; $l_d = 0.4$ in.
Dotted line: flat bars finished all over, $a = 1.34 \times 0.473$ in.; $l_d = 0.335$ in.
" C: Full line: flat bars finished on edges only, $a = 1.6 \times 0.51$ in.; $l_d = 0.44$ in.
Dotted line: flat bars finished all over, $a = 1.34 \times 0.473$ in.; $l_d = 0.375$ in.

In these rounds the spaces are $l_d = 0.56\sqrt{a}$, in flat bars $l_d = 0.43\sqrt{a}$.

FIG. 105. (152)

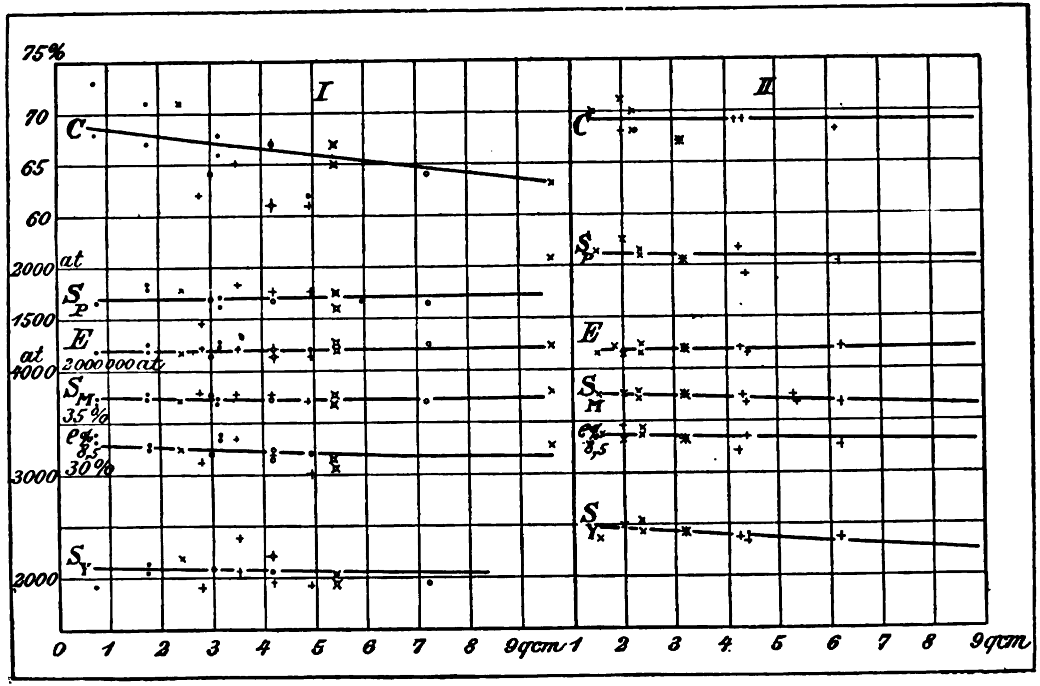


FIG. 106. (153)

Effect of Sectional Area on Results of Tension-tests.

Group I: Low Steel (Flusseisen) (billets), rounds and flats.
" II: " " " (bars), " " "

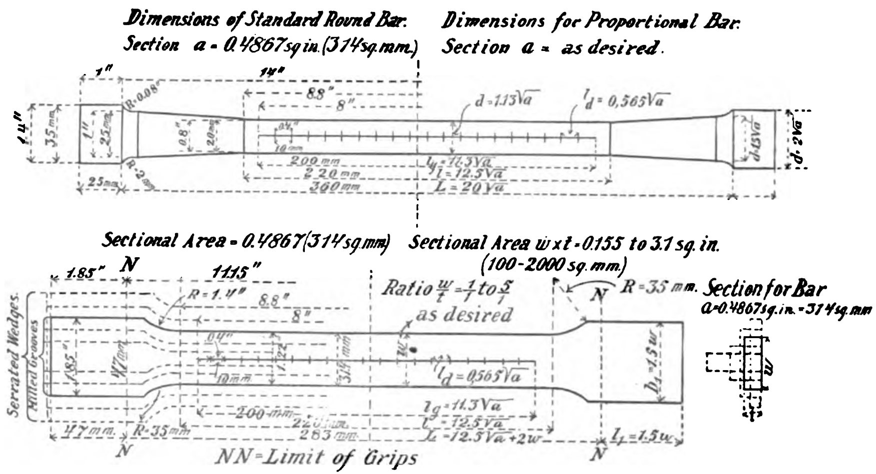

Dimensions of Standard Round Bar.
Section a = 0.4867 sq. in. (314 sq. mm.)
Dimensions for Proportional Bar.
Section a = as desired.
Sectional Area = 0.4867 (314 sq. mm.)
Sectional Area w x t = 0.155 to 3.1 sq. in.
(100-2000 sq. mm.)
Ratio w/t = 1/1 to 5/1
as desired
Section for Bar
a=0.4867 sq. in. = 314 sq. mm
Serrated Wedges.
Milled Grooves
NN = Limit of Grips

FIG. 107.

(157)

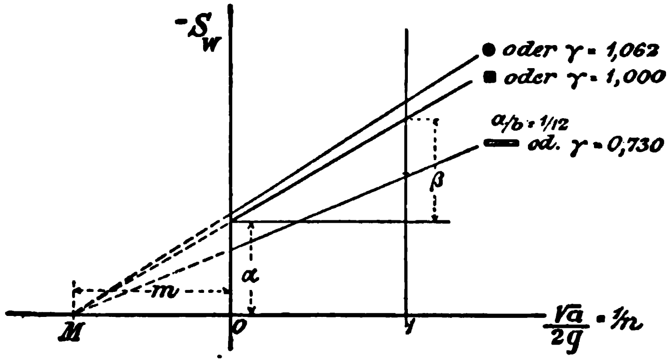


Fig. 108.

(163)

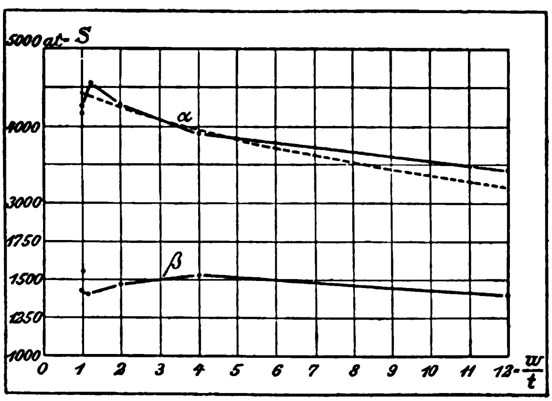


Fig. 109.

(165)

Cast Iron. Dependence of α and β on relation of $w : t$ of the rectangular section.

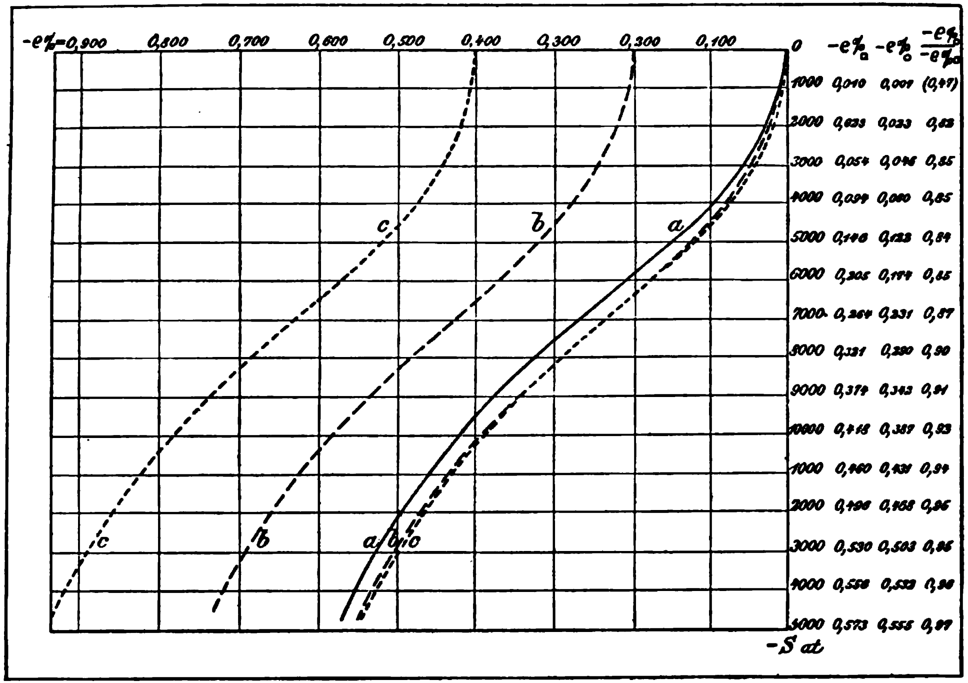


Fig. 110.

(166)

Effect of Shape of Test-pieces on Crushing $-e\%$ during Crushing-test.

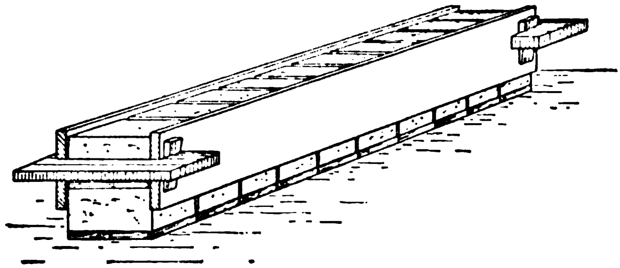


Fig. 111.

(167)

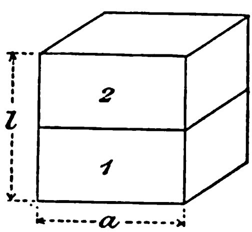


Fig. 112.

(167)

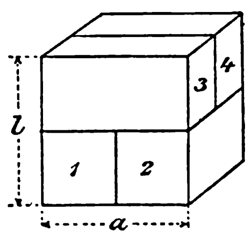


Fig. 113.

(167)

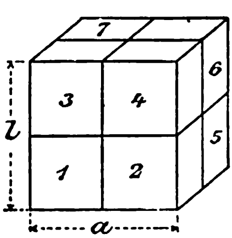


Fig. 114.

(167)

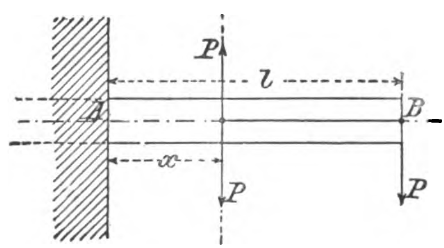


Fig. 115.

(168)

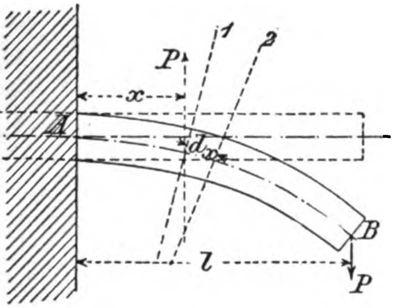


Fig. 116.

(169

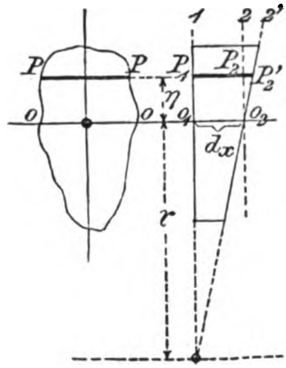


Fig. 117.

(169)

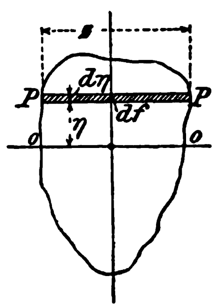


Fig. 118.

(170)

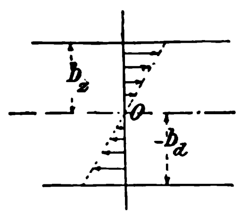


Fig. 119.

170

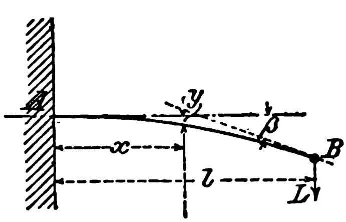


Fig. 120.

(170)

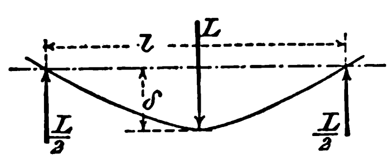


Fig. 121.

(172)

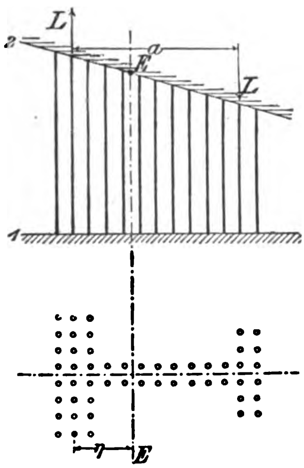


Fig. 122.
(172)

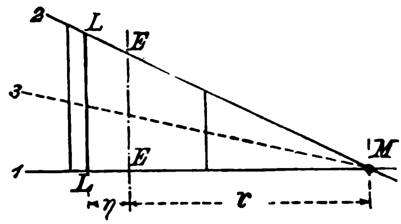


Fig. 123.
(172)

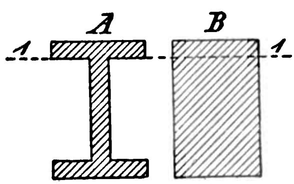


Fig. 124.
(172)

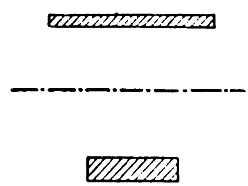


Fig. 125.
(172)

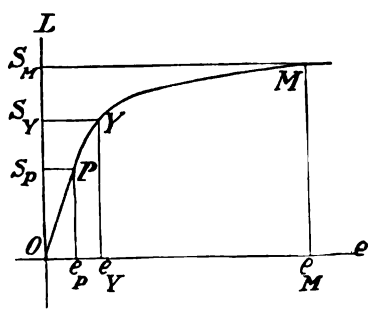


Fig. 126.
(176)

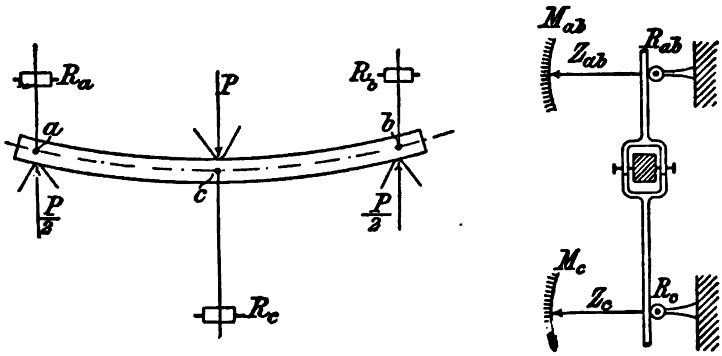


Fig. 127.

(180)

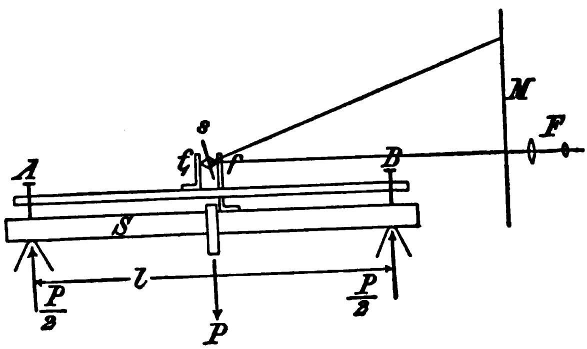


Fig. 128.

(181)

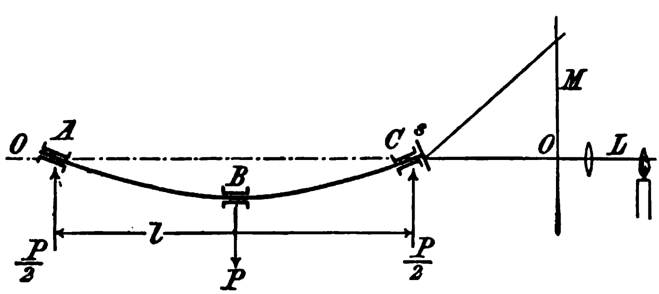


Fig. 129.

(182)

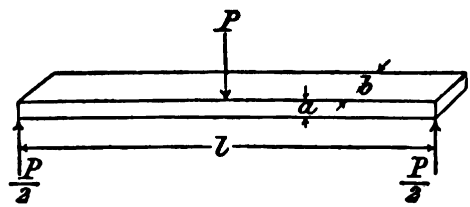


Fig. 130.

(184)

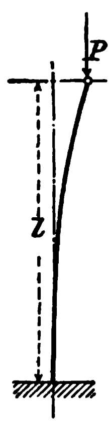


Fig. 131.

(189)

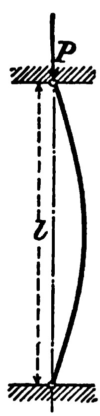


Fig. 132.

(189)

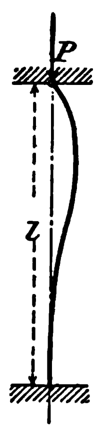


Fig. 133.

(189)

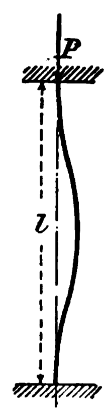


Fig. 134.

(189)

(192)

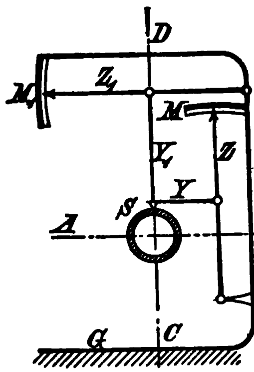


Fig. 135.

(192)

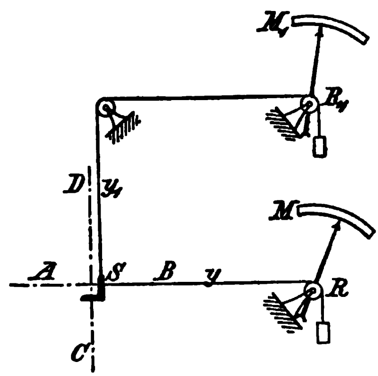


Fig. 136.

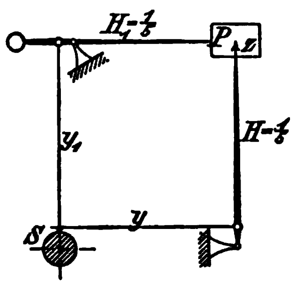


Fig. 137.

(194)

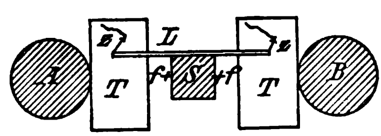


Fig. 138.

(194)

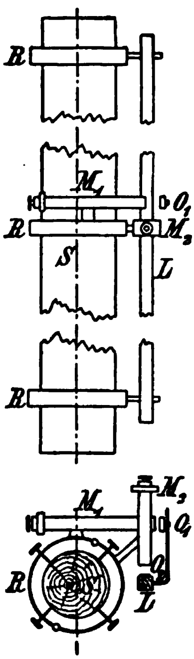


Fig. 139.

(196)

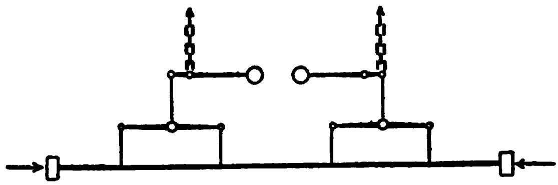


Fig. 140.

(197)

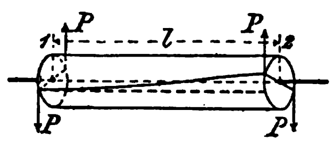


Fig. 141.

(200)

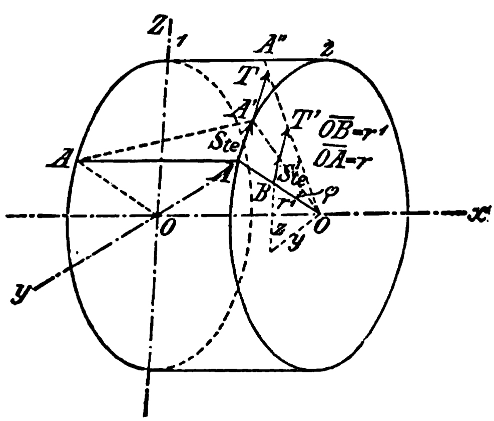


Fig. 142.

(200)

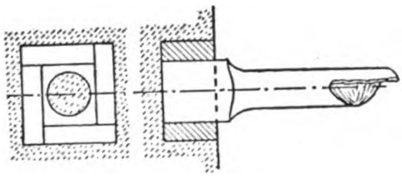


Fig. 143.

(203)

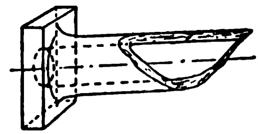


Fig. 144.

(203)

(203)

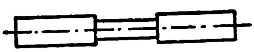


Fig. 145.

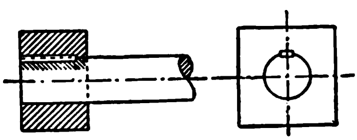


Fig. 146.

(203)

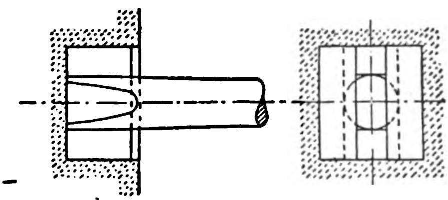


Fig. 147.

(203)

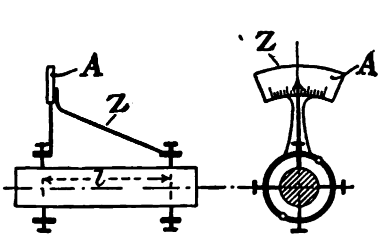


Fig. 148.

(204)

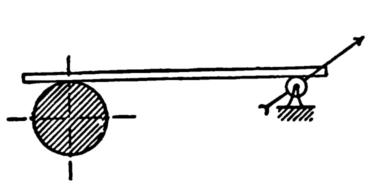


Fig. 149.

(204)

(205)

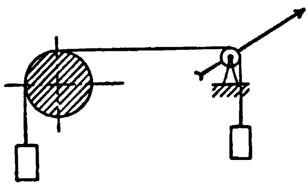


Fig. 150.

(205)

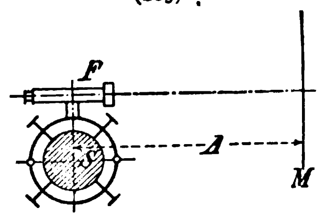


Fig. 151.

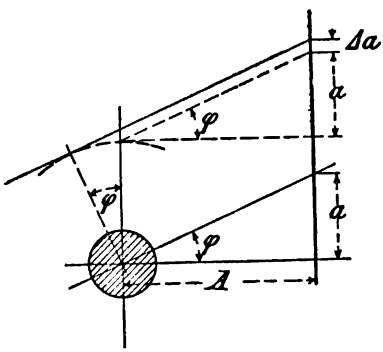


Fig. 152.

(205)

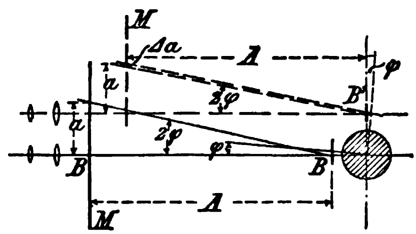


Fig. 153.

(205)

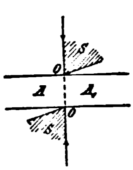


Fig. 154.

(214)

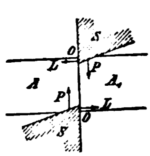


Fig. 155.

(214)

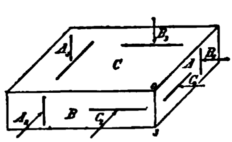


Fig. 156

(215)

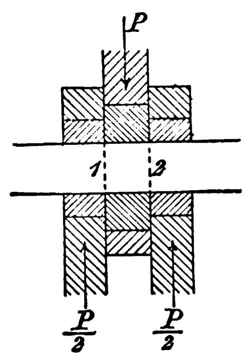


Fig. 157.

(216)

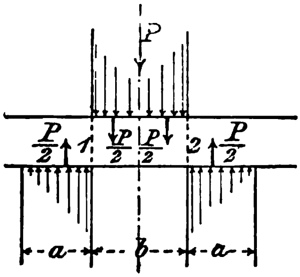


Fig. 158.

(216)

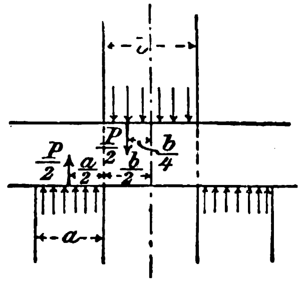


Fig. 159.

(216)

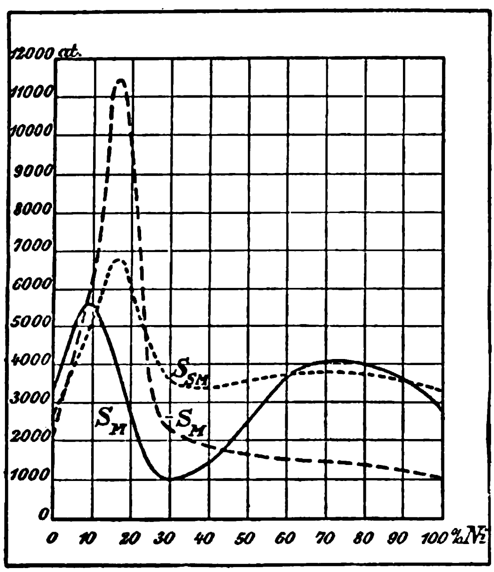


Fig. 160.

(216)

Properties of Iron. Nickel Alloys with increasing amounts of Nickel.

S_M = Tenacity ; $-S$ = Crushing Strength ; S_{SM} = Shearing Strength.

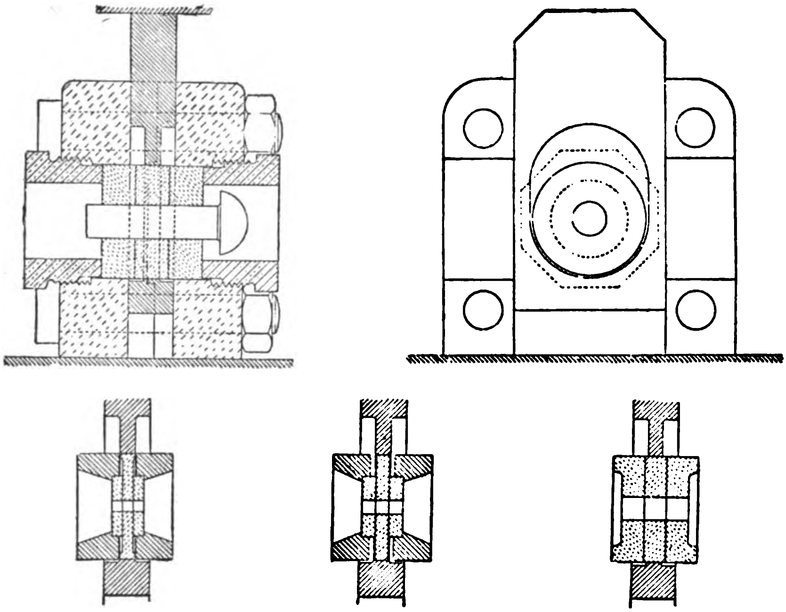


Fig. 161.

(216)

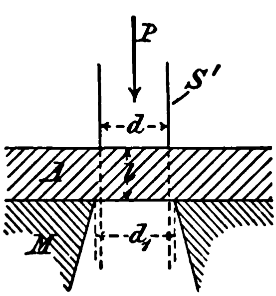


Fig. 162.

(217)

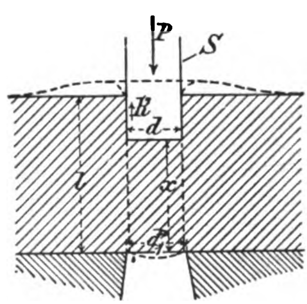


Fig. 163.

(217)

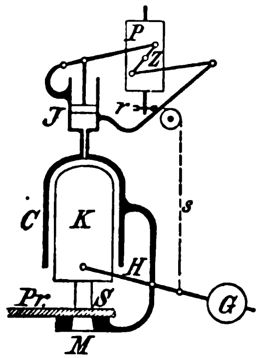


Fig. 164.

(217)

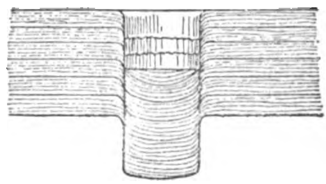


Fig. 165.

(218)

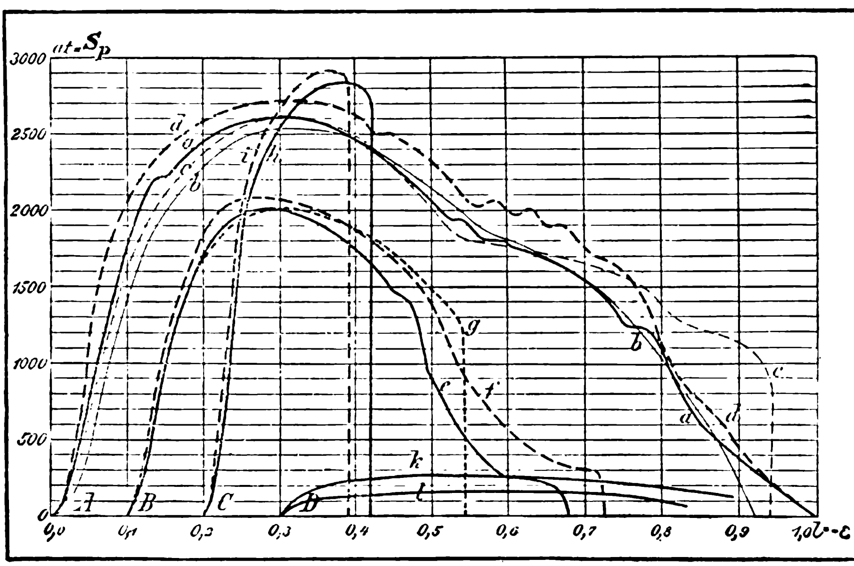


FIG. 166. (219.) **Diagrams of Punching-tests.**

All dimensions in inches. d = diam. of punch; d_1 = diam. of die; t = thickness of plate. Heavy lines = flat punch; fine lines = concave punch.

A. Fine-grained Iron. 2.2 in. × 0.52 in.; $d = 0.8$; $t = 0.52$; $t/d = 0.675$; d_1/d 1.050. In all cases perforation was noiseless. Time of test *a* and *b* 12 to 14 min.; *c* and *d* less than 1 min. Effect of speed plainly marked.

B. Sheet Copper. $d = 0.8$; $t = 0.398$; $t/d = 0.51$. In test *e*, $d_1 = 0.792$; *f*, $d_1 = 0.8077$: *g*, $d_1 = 0.8274$; hence $d_1/d = 1.005$, 1.025, 1.050; time 2 to 4 min.

C. Sheet Brass, untreated. $d = 1$ in.; $t = 0.4$; $t/d = 0.40$. In test *h*, $d_1 = 1.024$; *i*, $d_1 = 1.0047$; hence $d_1/d = 1.040$; 1.002; time h = 2 min.; i = 13 min.; effect of speed noticeable.

D. Cast Lead. Diam. of ingot = D; for *k*: $D = 2.83$; $d = 0.8$; $d_1 = 0.8077$; $t = 1.615$: $t/d = 2.05$; $d_1/d = 1.025$. For *l*: $D = 0.8$; $d_1 = 0.792$; $t = 1.146$; $t/d = 1.46$; $d_1/d = 1.005$.

The pieces were not punched quite through, the plug was raised 1 in. in test *k* and 0.93 in. in test *l*.

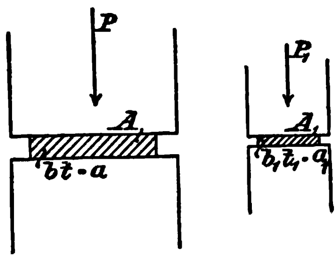


Fig. 167

(220)

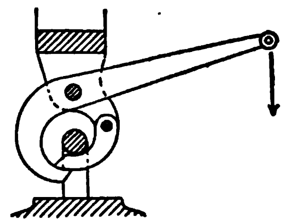


Fig. 169.

(226)

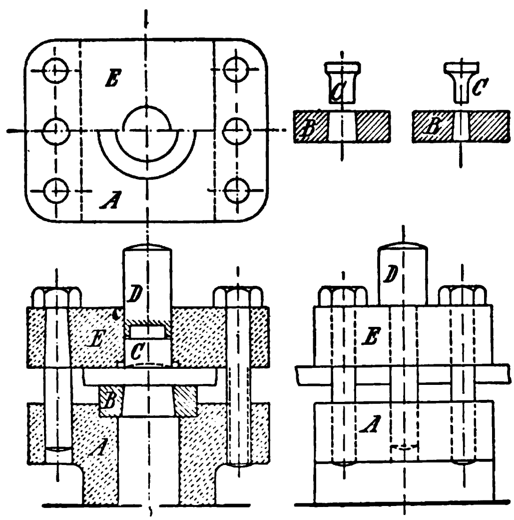


Fig. 168.

(222)

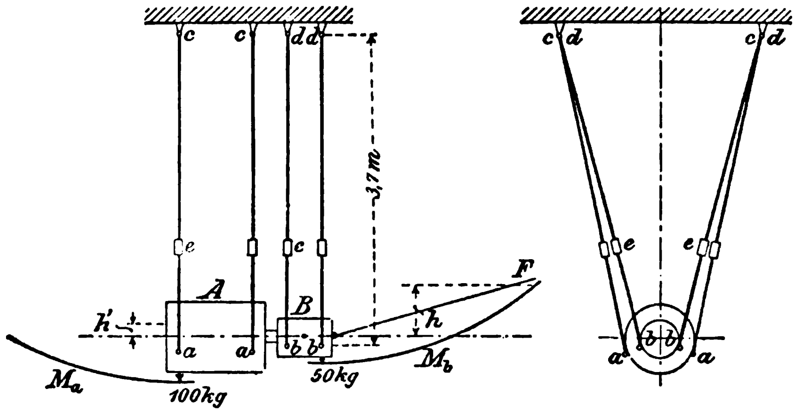


Fig. 170.
(227)

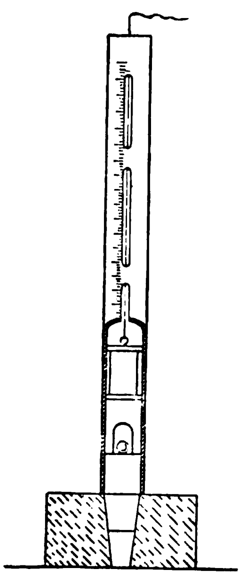


Fig. 171.
(229)

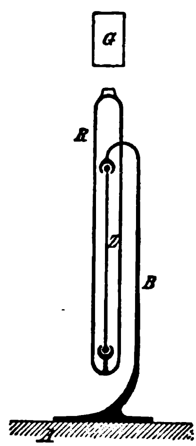


Fig. 172.
(229)

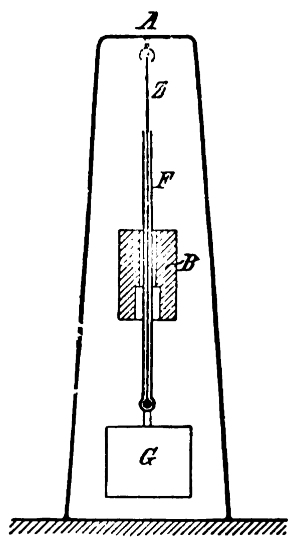


Fig. 173.
(229)

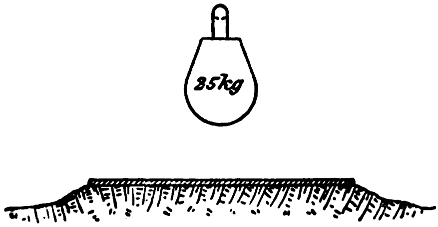


Fig. 174.

(234)

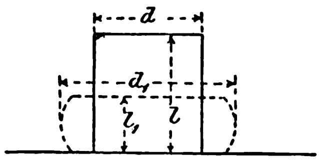


Fig. 175.

(238)

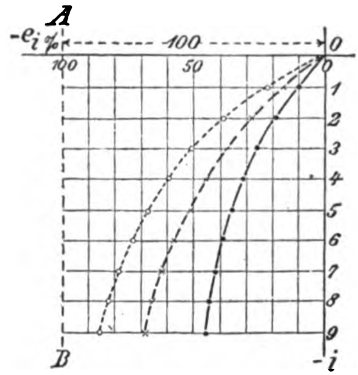


Fig. 176.

(240)

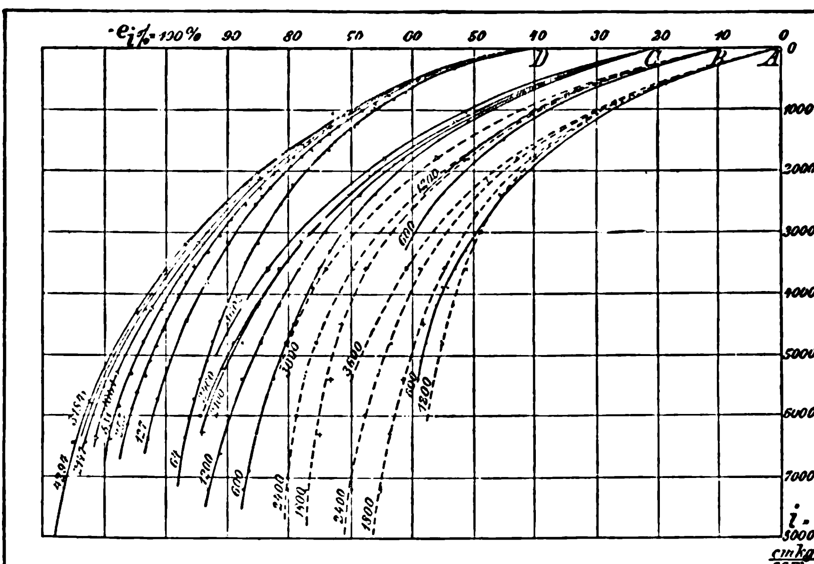


Fig. 177.

(243)

Groups A to C. Rolled Brass. Full lines, struck by ball I; broken lines, struck by ball II; $d = l$ for Group $A = 0.5$ in.; $B = 0.51$ in.; $C = 0.4$ in. The lower ends of lines are marked with the specific impact in $\frac{Cm\ kg}{ccm}$ of each blow.

Group D. Copper. Represented same as in A to C.

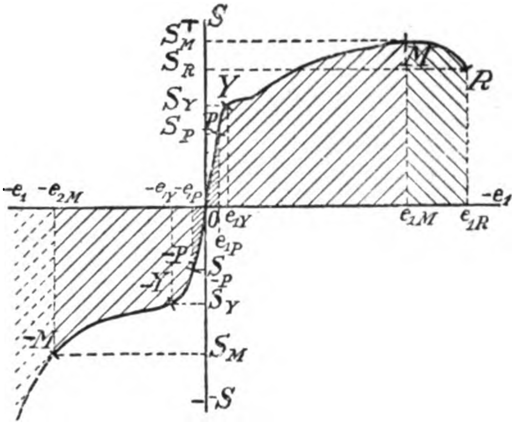


FIG. 178. (243)

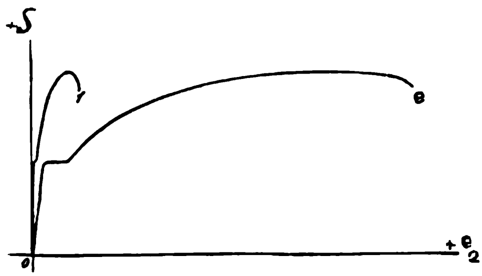


Fig. 179.

(243)

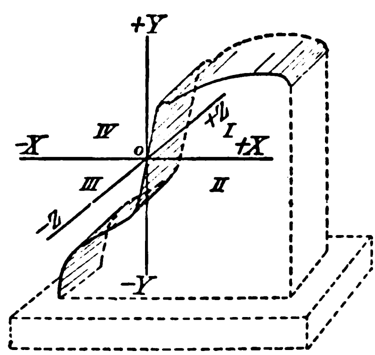


Fig. 180.

(243)

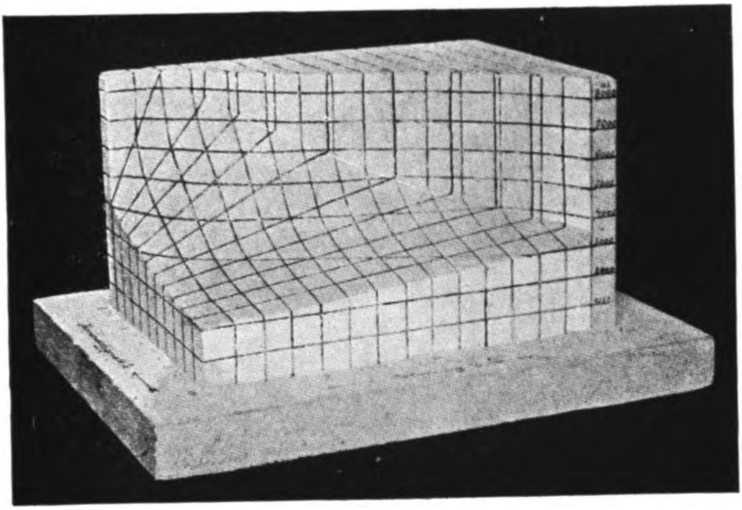


FIG. 181.

(243)

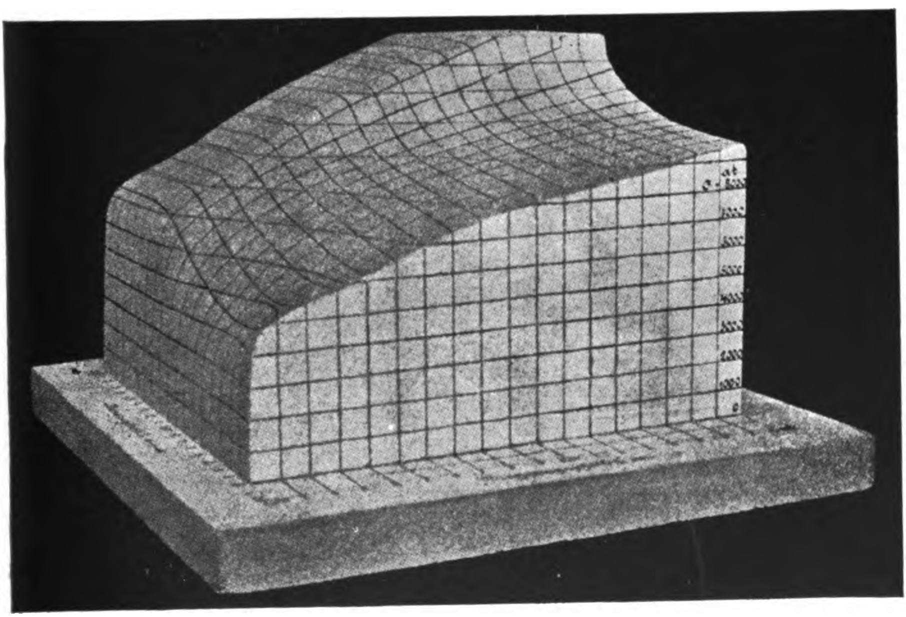


FIG. 182

(243)

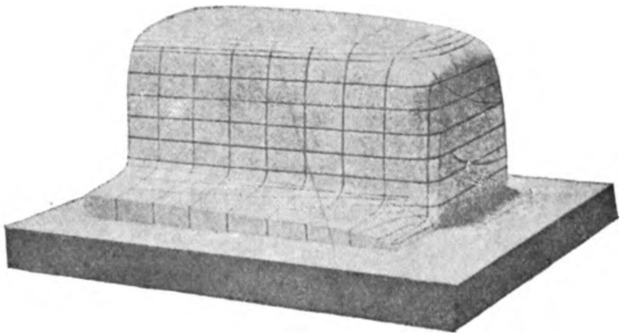


FIG. 183. (243)

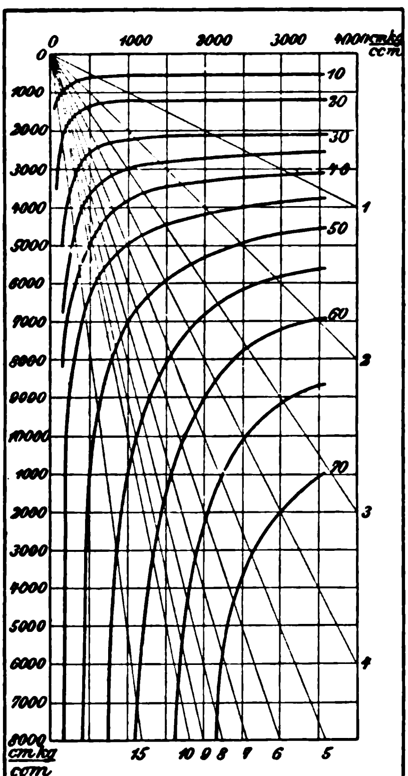


Fig. 184.

(244)

Rolled Brass, $d = d = 0.6$ in. Ball I.

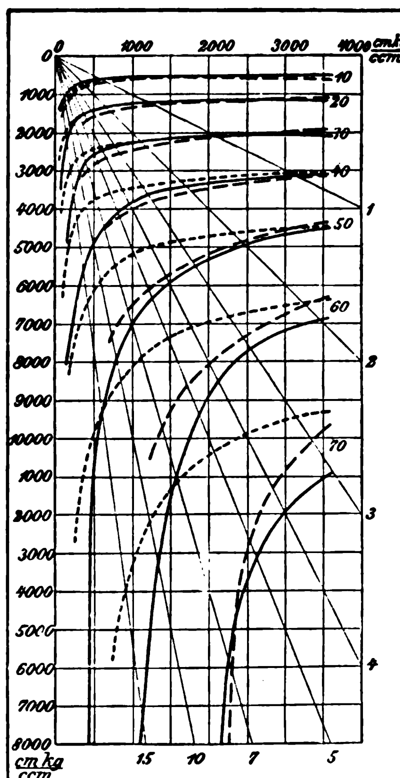


Fig. 185.

(244)

Rolled Brass.

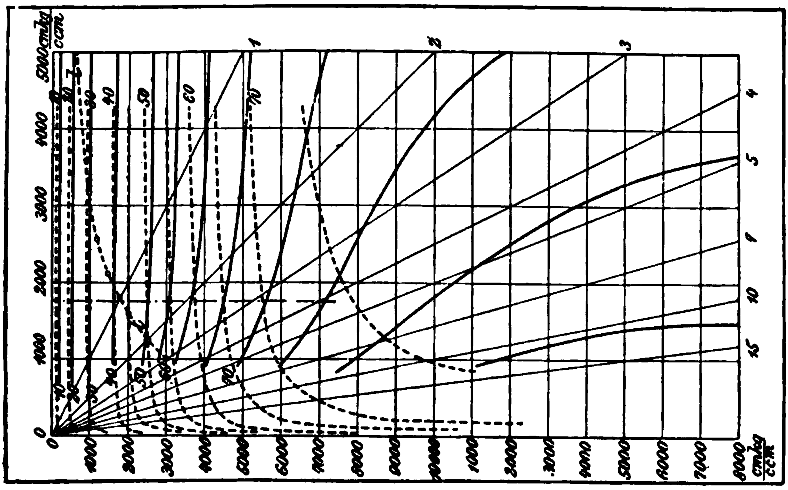


Fig. 187.
(249)

Rol.ed Brass.

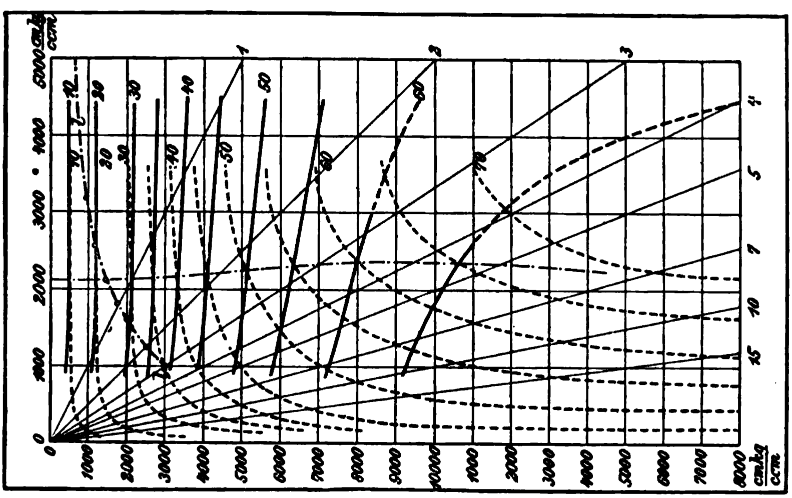


Fig. 186.
(249)

Bar Copper.

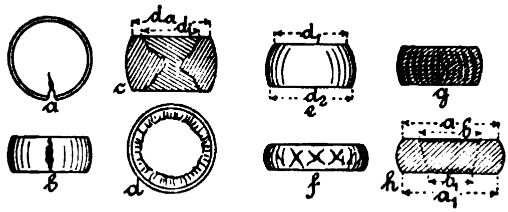


Fig. 188.

(253)

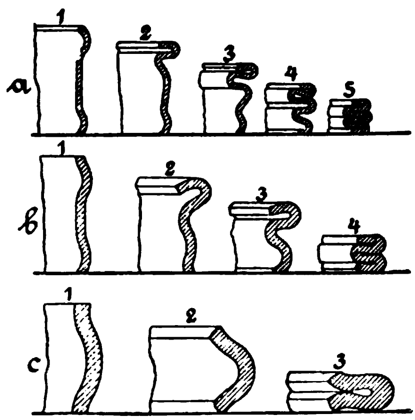
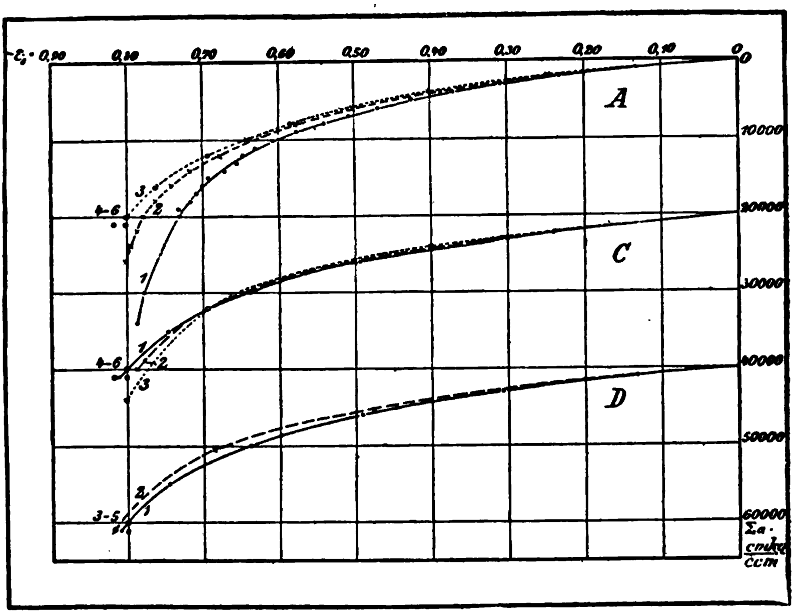


Fig. 189.

(255)



$-\varepsilon_i$ = 0,90
0,80
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0
0
10000
20000
30000
40000
50000
60000
$\Sigma_a \cdot \frac{cmkg}{ccm}$
A
C
D
4-6
3
2
1
4-6
1
2
3
3-5
2
1

Fig. 190.

(259)

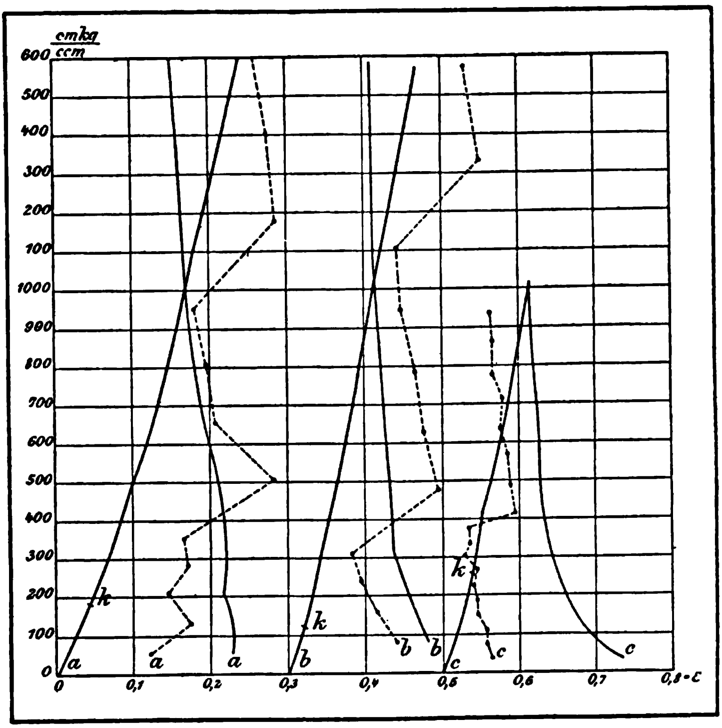

cmkg/ccm
600
500
400
300
200
100
1000
900
800
700
600
500
400
300
200
100
0
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8 = ε
a
a
a
k
b
b
b
k
c
c
c
k

Fig. 191.

(261)

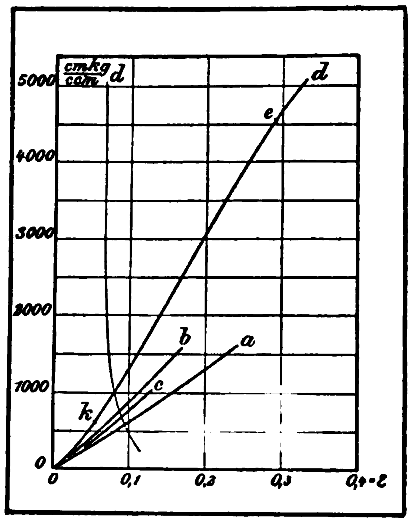


Fig. 192.

(261)

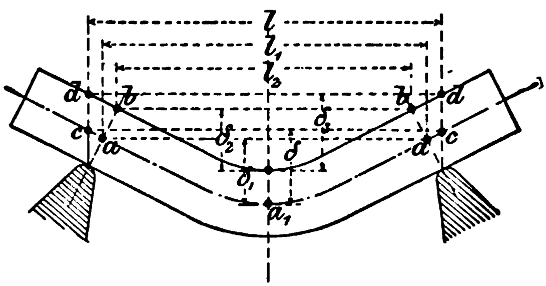


Fig. 193.

(268)

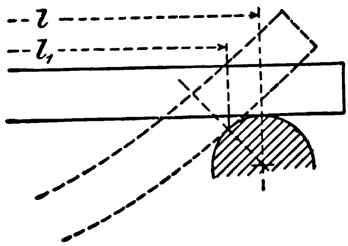


Fig. 194.
(268)

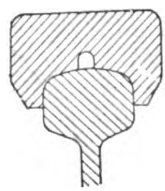


Fig. 195.
(271)

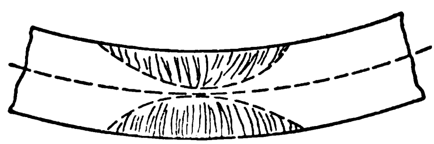


Fig. 197.
(273)

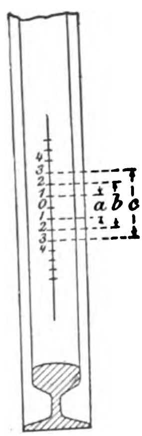


Fig. 196.
(271)

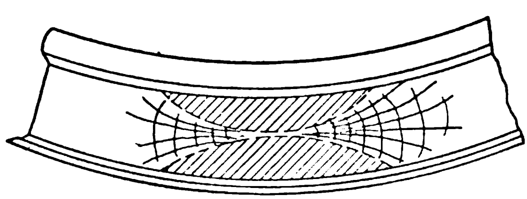


Fig. 198.
(274)

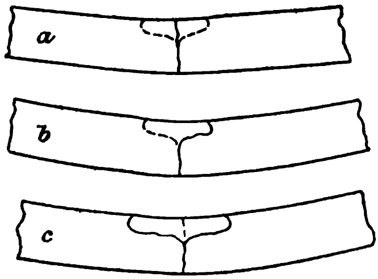


Fig. 199.

(274)

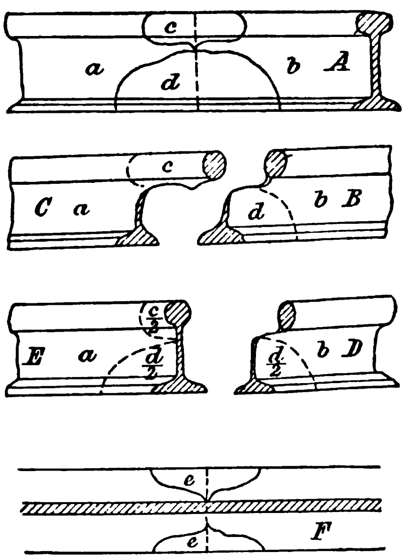


Fig. 200.

(275)

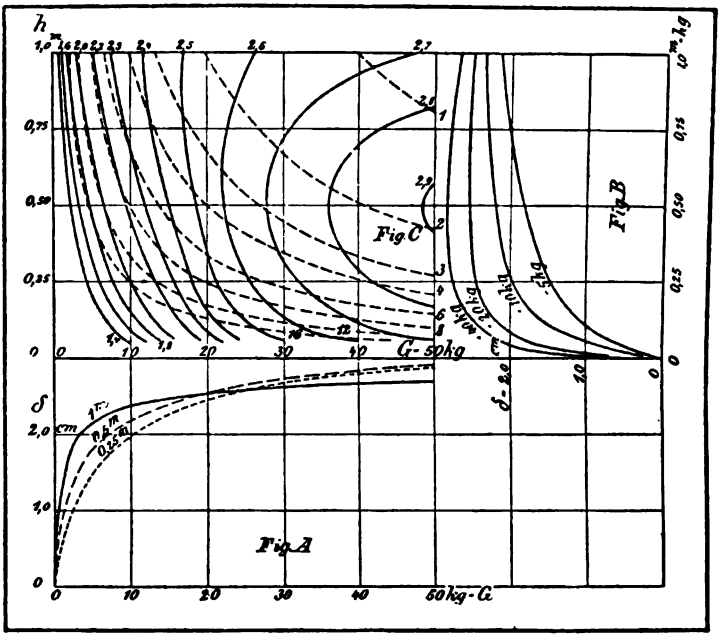


Fig. 201.
(277)

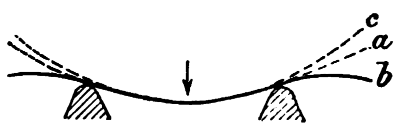


Fig. 202.
(281)

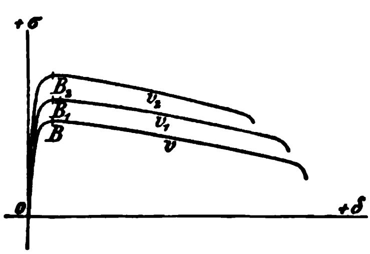


Fig. 203.
(288)

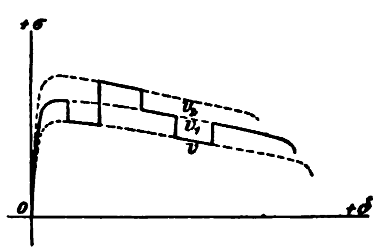


Fig. 204.
(290)

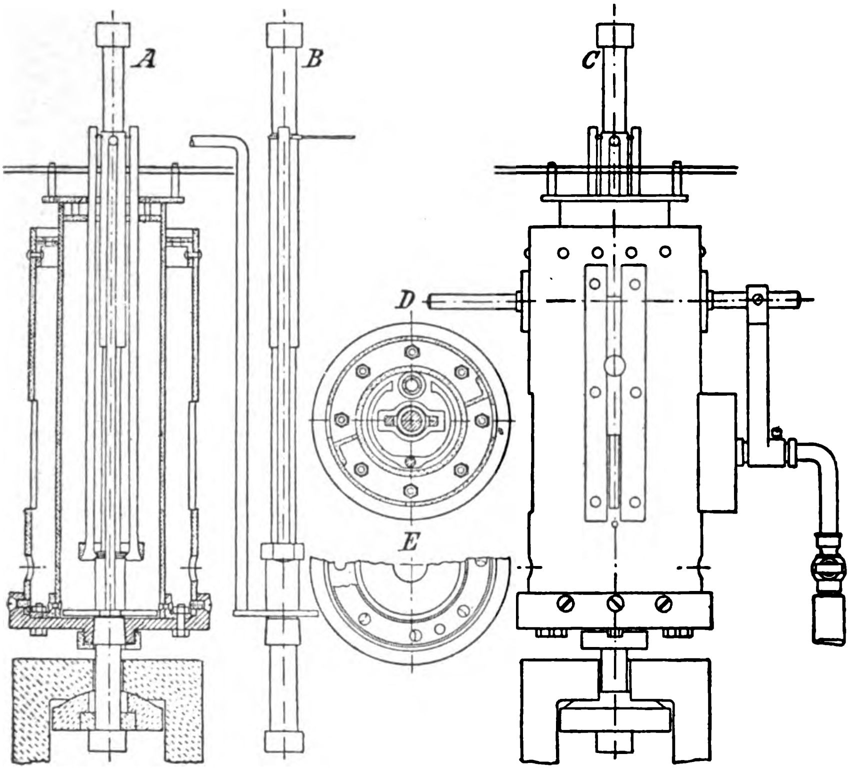


Fig. 205.

(299)

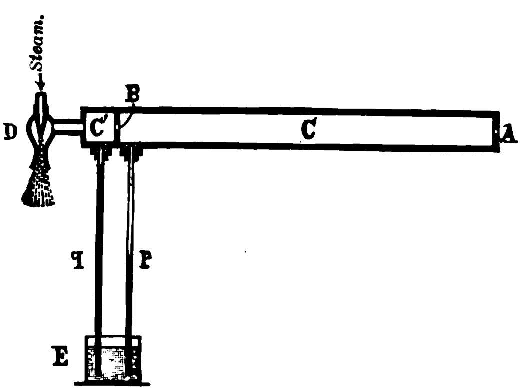


FIG. 207a. (308a)

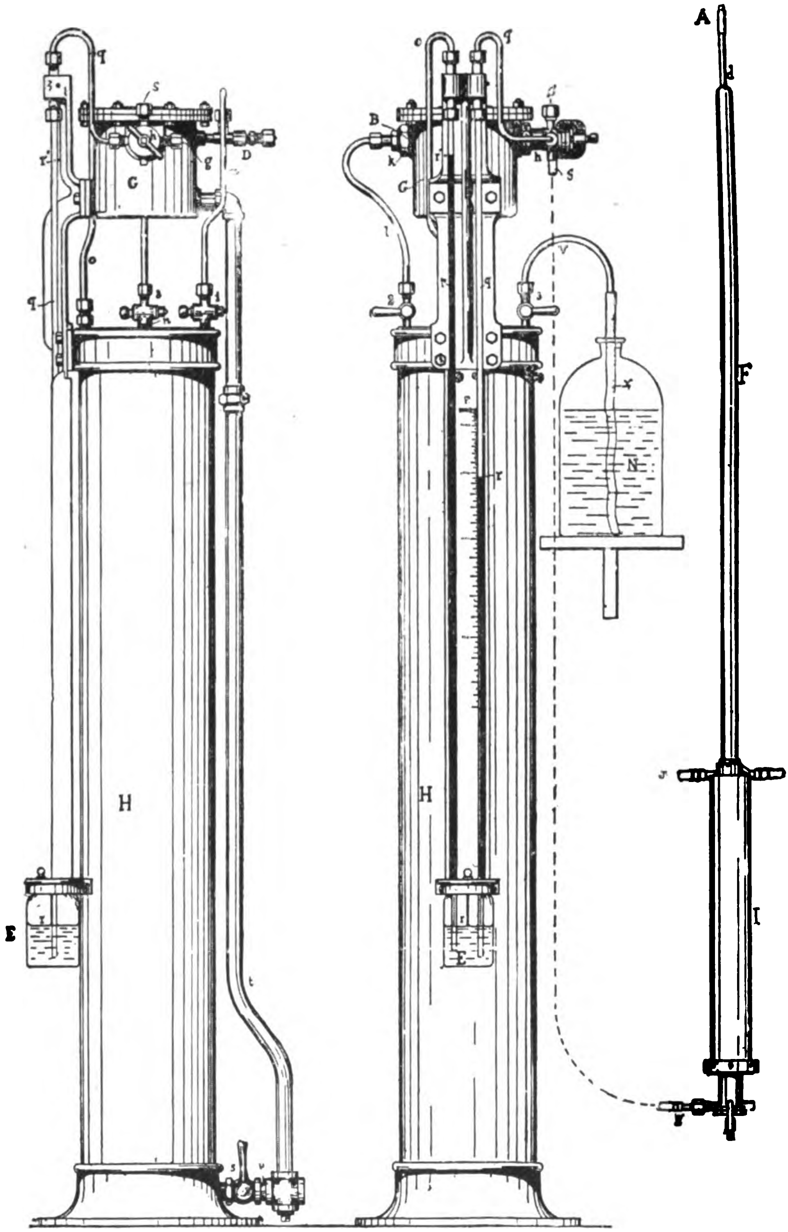


FIG. 207b.
(308b.)

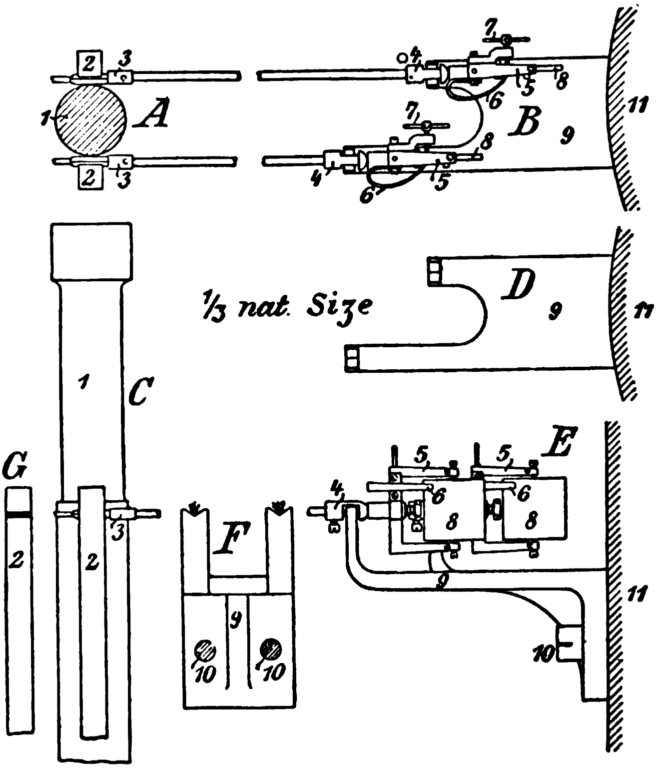


Fig. 206.
(300)

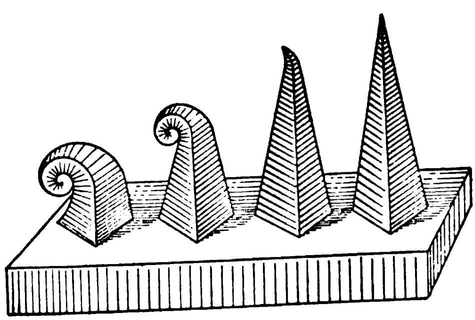


Fig. 207.
(306)

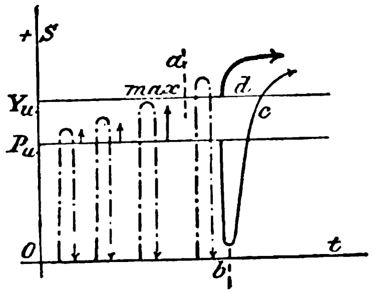


Fig. 208.

(314)

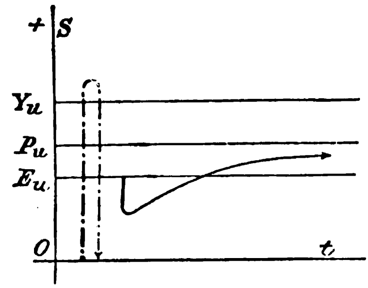


Fig. 209.

(314)

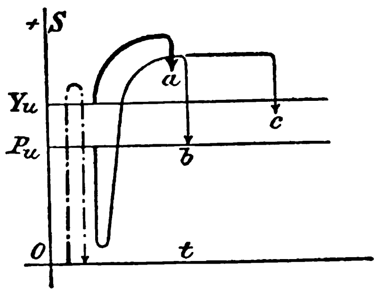


Fig. 210.

(314)

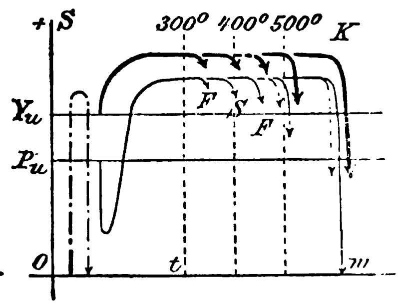


Fig. 211.

(314)

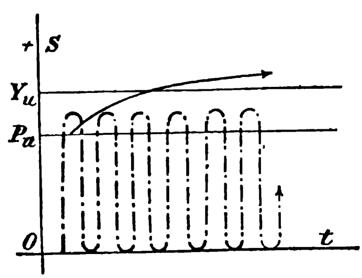


Fig. 212.

(314)

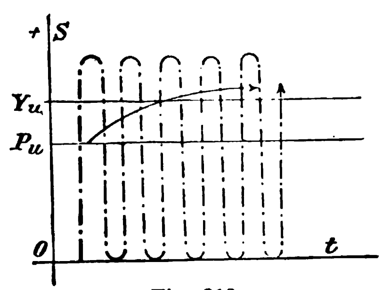


Fig. 213.

(314)

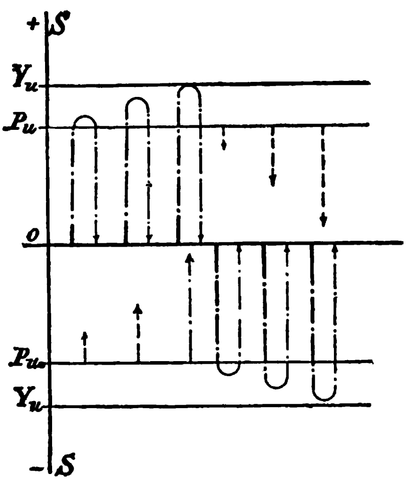


Fig. 214.
(314)

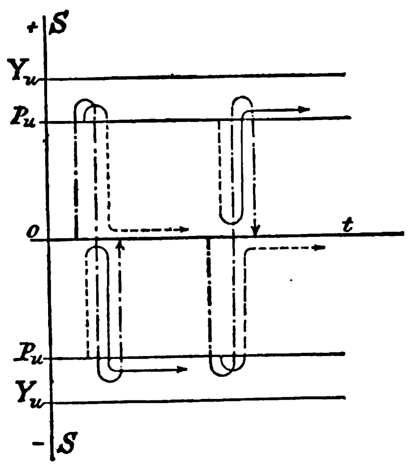


Fig. 215.
(314)

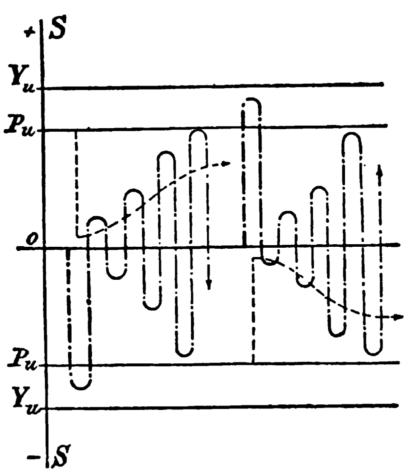


Fig. 216.
(314)

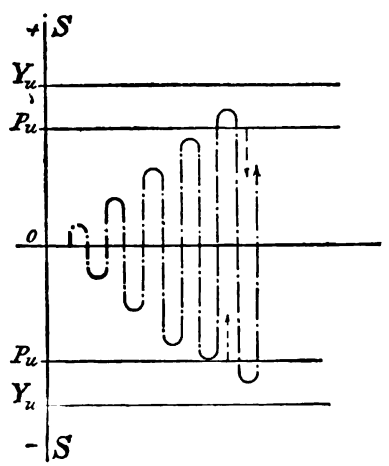


Fig. 217.
(314)

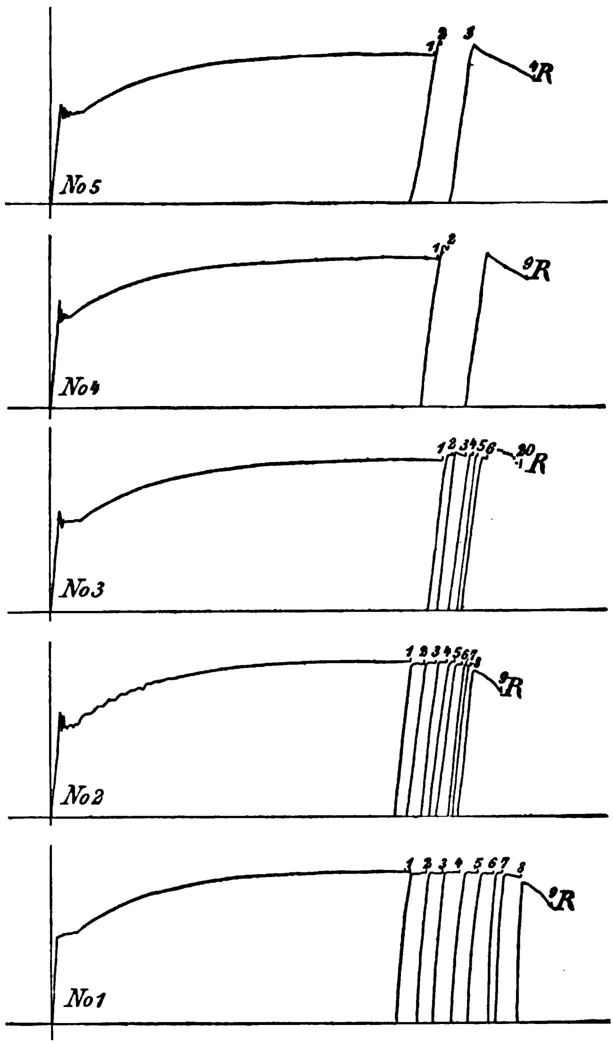

No 5
1
2
3
4R
No 4
1
2
9R
No 3
1 2 3 4 5 6
10R
No 2
1 2 3 4 5 6 7 8
9R
No 1
1 2 3 4 5 6 7 8
9R

Fig. 218.

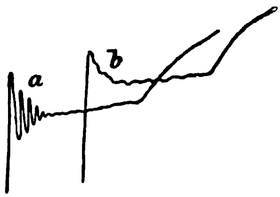


Fig. 219.
(314)

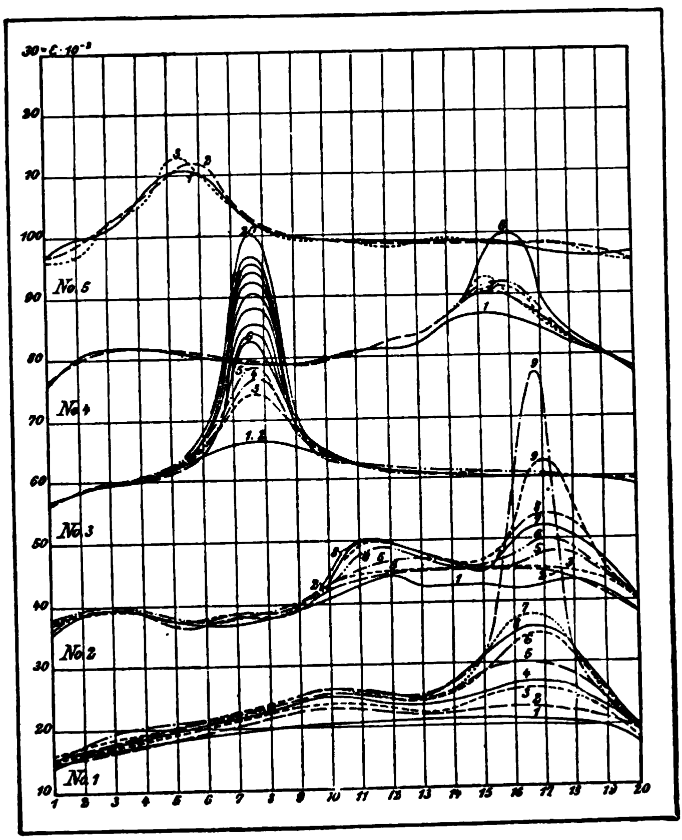


Fig. 220.
(314)

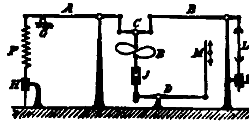


Fig. 222.

(316)

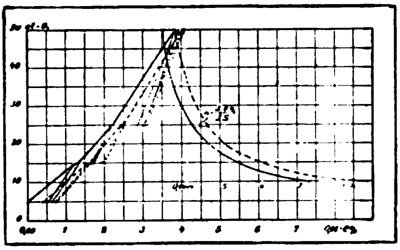


Fig. 221.

(314)

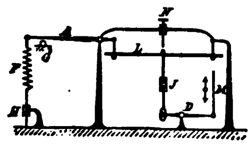


Fig. 223.

(317)

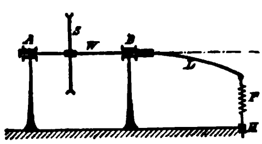


Fig. 224

(318)

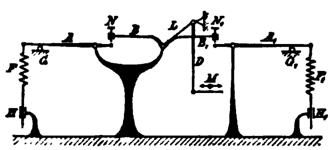


Fig. 225

(319)

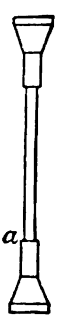


Fig. 226.

(321)

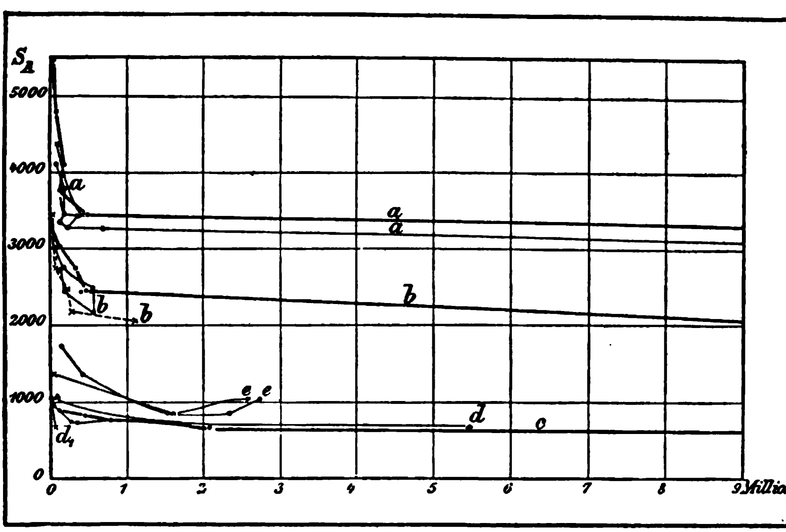


Fig. 227.

(322)

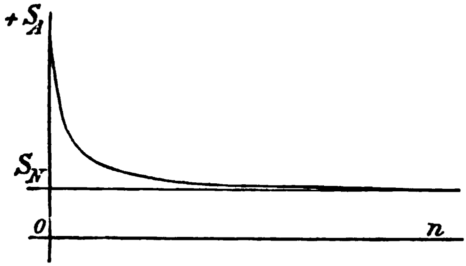


Fig. 228.
(323)

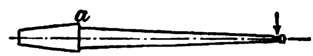


Fig. 229.
(323)

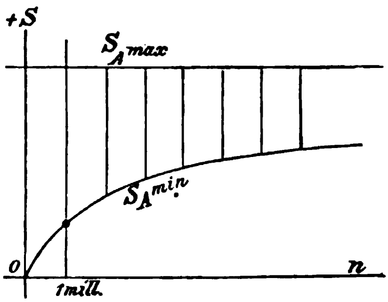


Fig. 230.
(324)

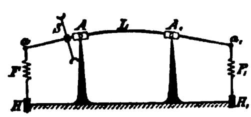


Fig. 231.
(325)

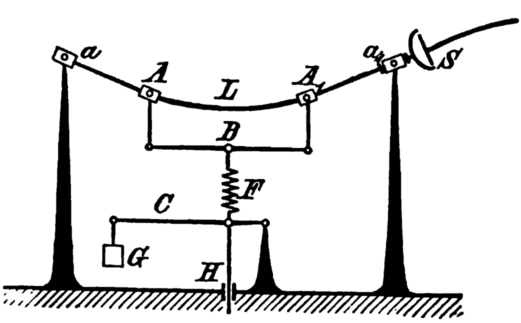


Fig. 232.
(326)

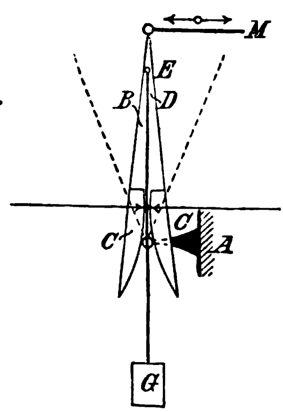


Fig 233.
(326)

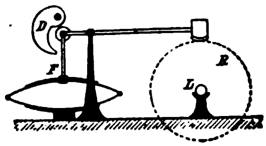


Fig. 234.

(330)

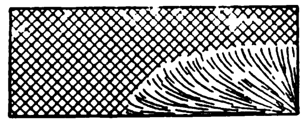


Fig. 235.

(334)

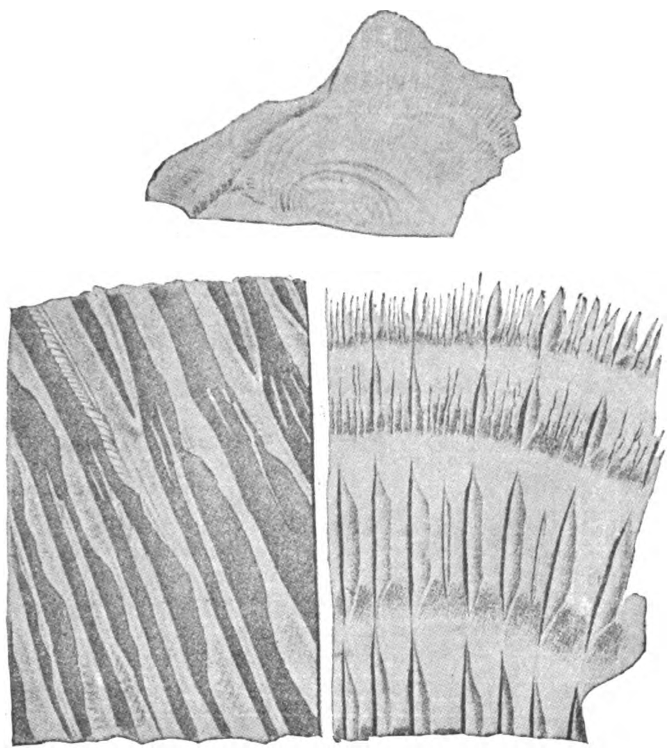


Fig. 236.

(335)

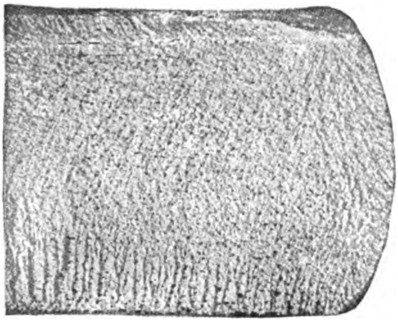


FIG. 237.
(335)

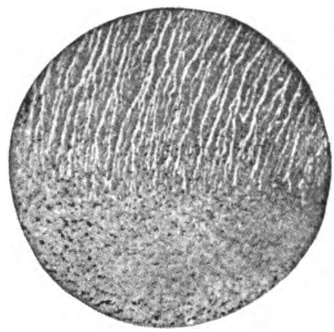


FIG. 238.
(355)

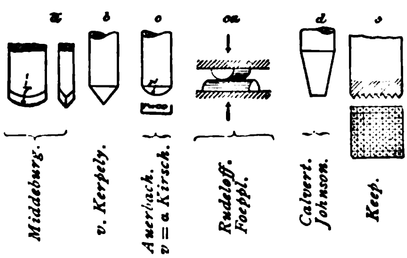


FIG. 239. (349)

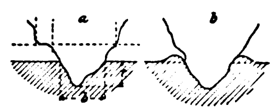


Fig. 241.
(357)

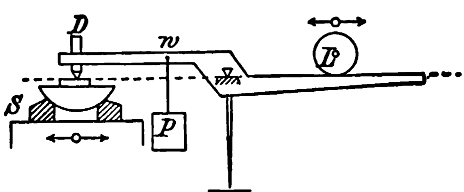


Fig. 240.
(357)

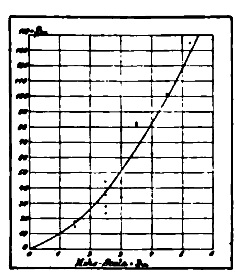


Fig. 242.
(359)

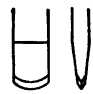


Fig 243.

(359)

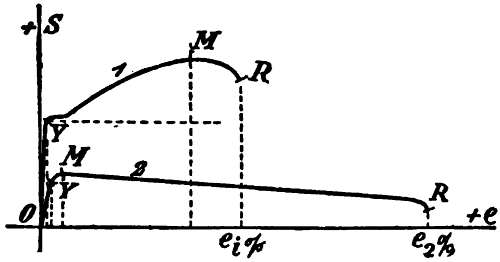


Fig. 244.

(364)

Toughness and Plasticity of Metals.

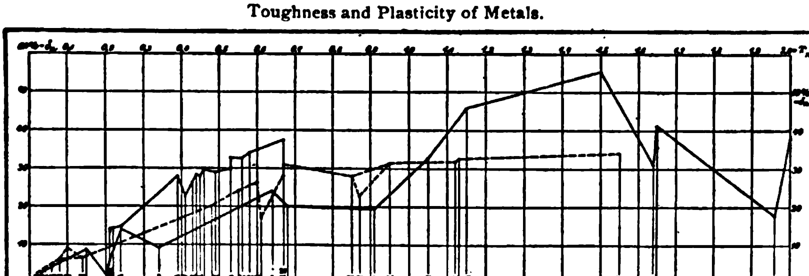


Fig. 245.

(367)

Effect of $\frac{S_Y}{S_M}$ and $e\%$ on Toughness T_n.

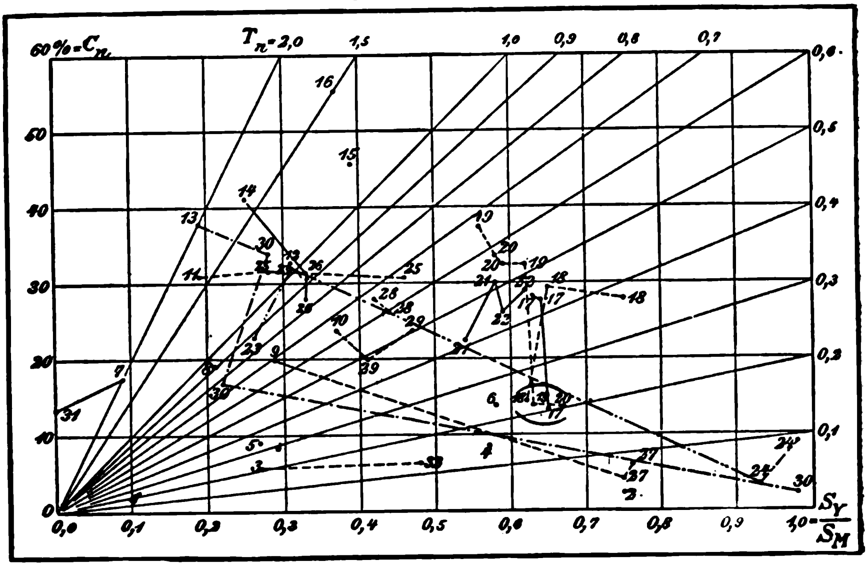


Fig. 246.
(367)

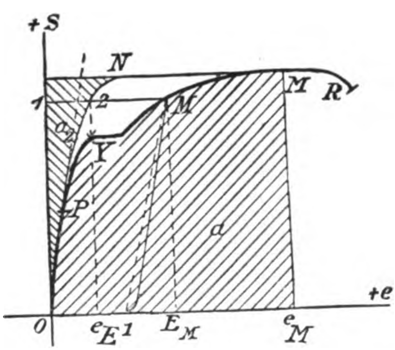


Fig. 247.
(371)

Fig. 248.
(373)

Fig. 249.
(373)

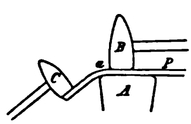


Fig. 250.
(374)

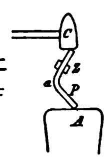


Fig. 251.
(374)

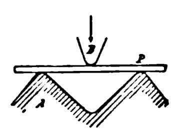


Fig. 252.
(375)

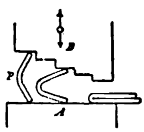


Fig. 253.
(375)

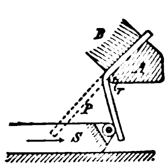


Fig. 254.
(376)

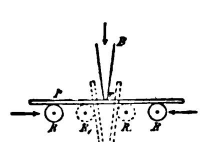


Fig. 255.
(377)

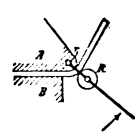


Fig. 256.
(378)

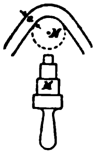


Fig. 257
(380)

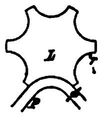


Fig. 258.
(380)

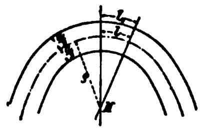


Fig. 259.
(381)


Fig. 260.
(381)

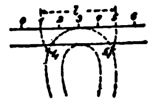


Fig. 261.
(383)

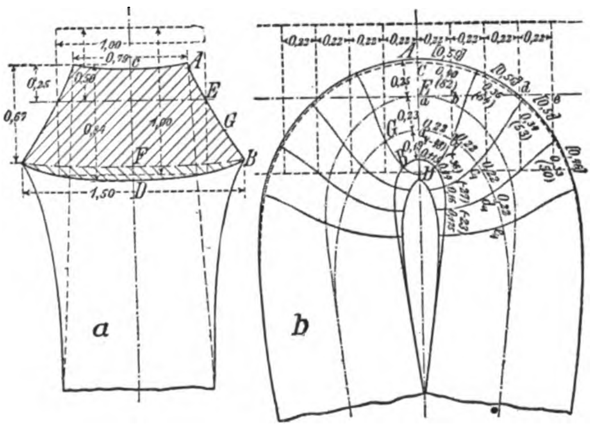


Fig. 262.
(383)

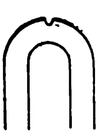


Fig. 263.
(387)


Fig. 264.
(388)

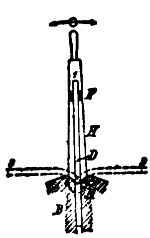


Fig. 265.
(394)

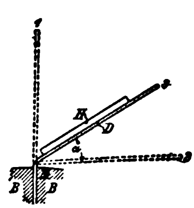


Fig. 266.
(396)

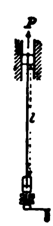


Fig. 267.
(397)

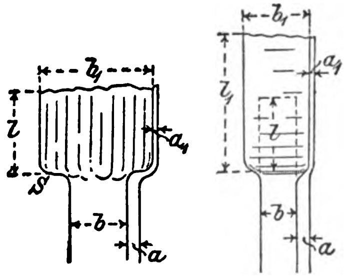


Fig. 268.

(399)

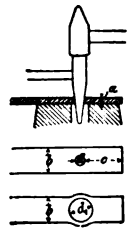


Fig. 269.

(401)

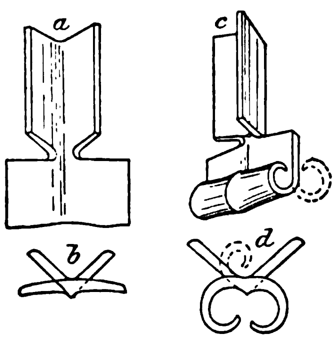


Fig. 270.

(405)

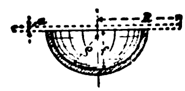


Fig. 271.

(405)

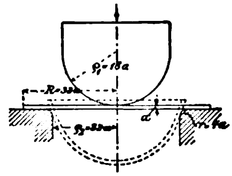


Fig. 272.

(405)

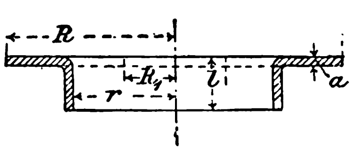


Fig. 273.

(406)

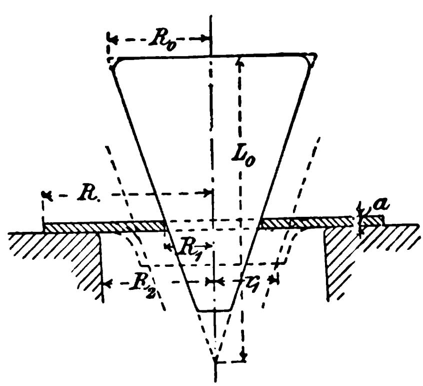
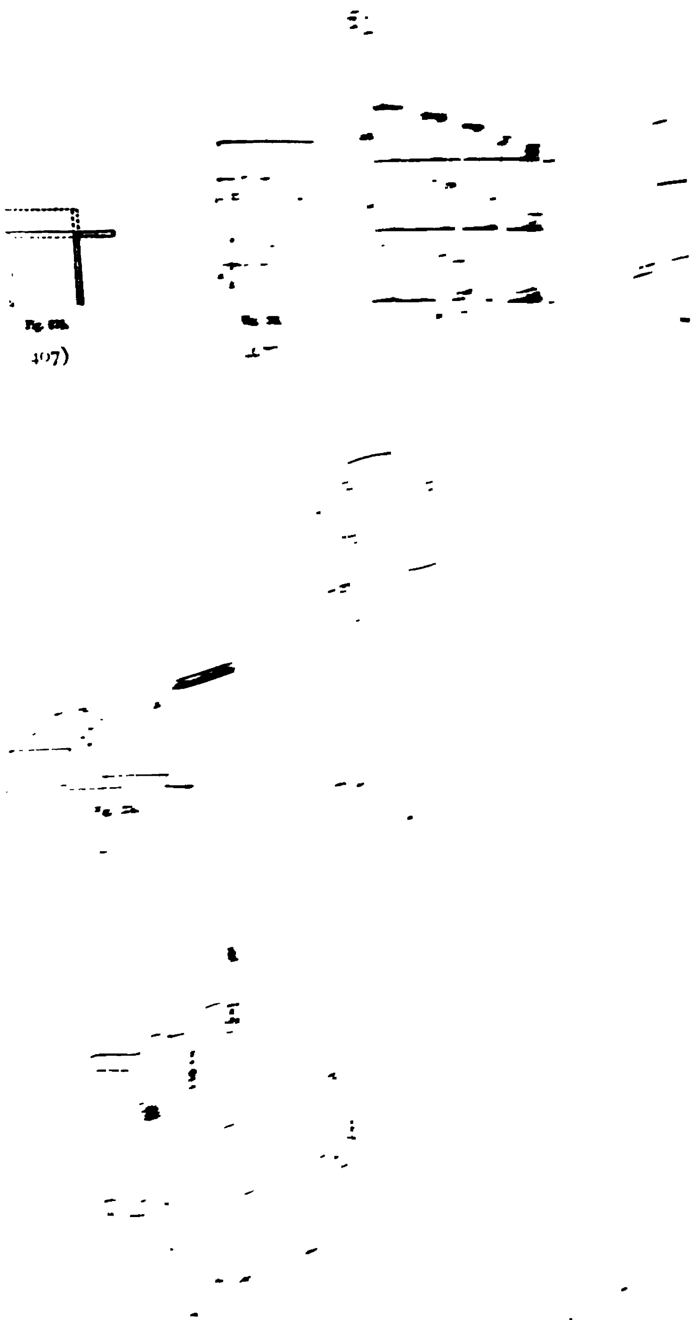


Fig. 274.

(406)



407)

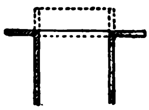


Fig. 275.
(407)

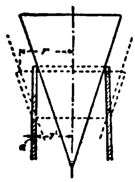


Fig. 276.
(407)


Fig. 277.
(408)

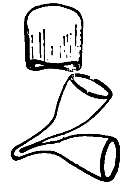


Fig. 278.
(408)

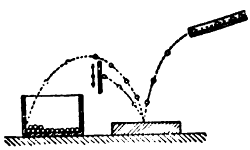


Fig. 279.
(409)

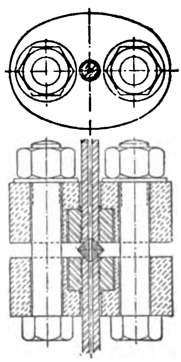


Fig. 280.
(411)

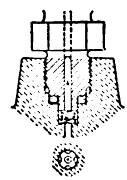


Fig. 281.
(411)

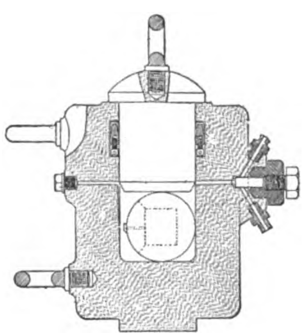


Fig. 282.
(413) (416)

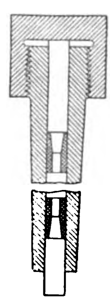


Fig. 283
(414) (416)

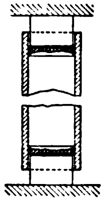


Fig. 284.

(416)

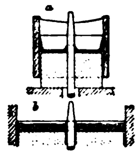


Fig. 285

(415)

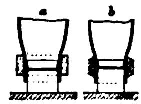


Fig. 286.

(416)

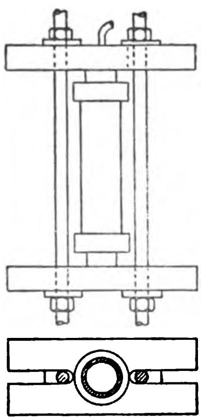


Fig. 287.

(417)

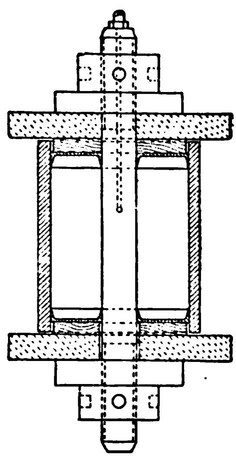


Fig. 288.

(417)

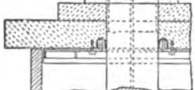


Fig. 289.

(418)

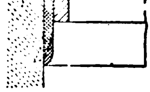


Fig. 290.

(418)

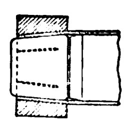


Fig. 291.

(420)

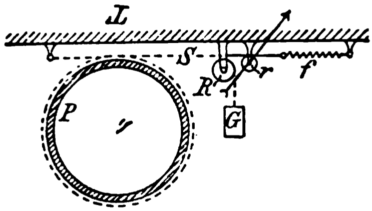


Fig. 292.
(421)

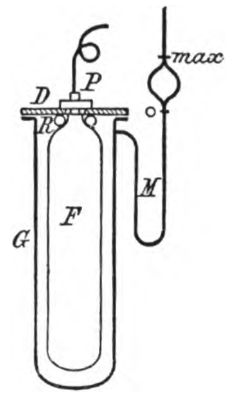


Fig. 293.
(423)

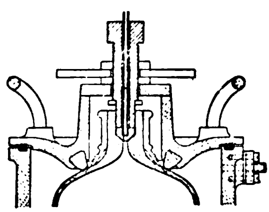


Fig. 294.
(423)

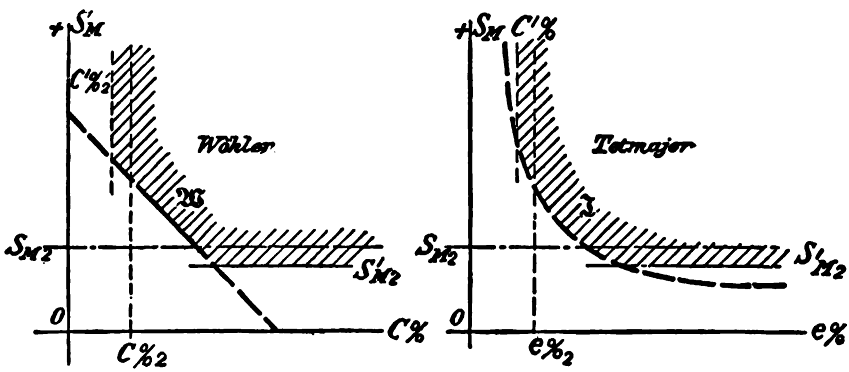


Fig. 295.
(432)

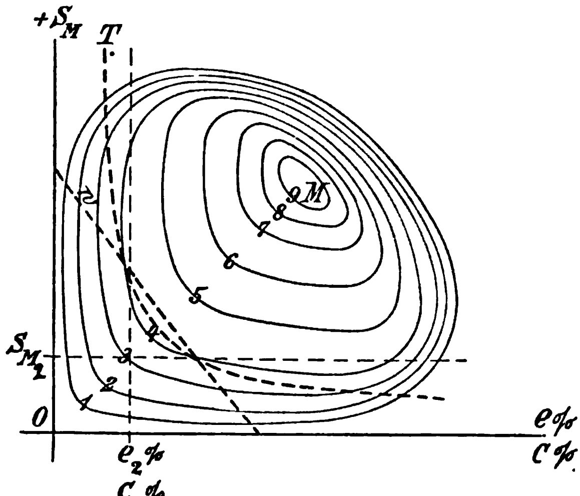


Fig. 296.

(435)

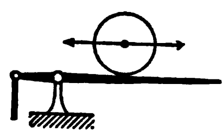


Fig. 297.

(444)

Fig. 298.

(444)

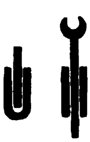


Fig. 299.

(444)

Fig. 300.

(444)

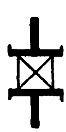


Fig. 301.

(444)

Fig. 302.

(444)

Fig. 303.

(444)

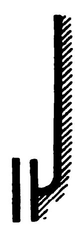
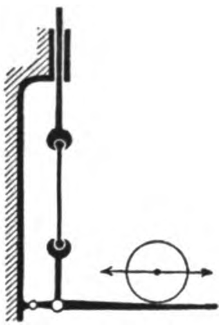


Fig. 304.

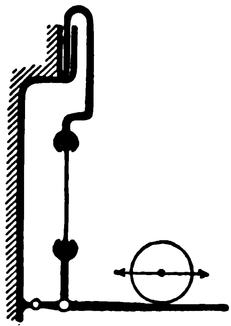
(444)

Fig. 305.



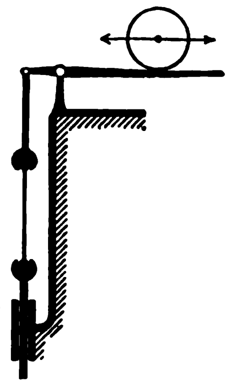
(445)

Fig. 306.



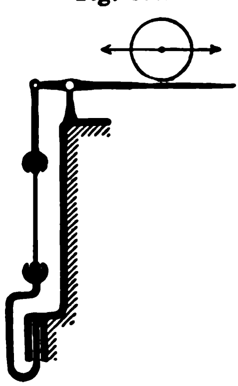
(445)

Fig. 307.



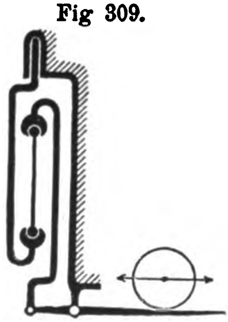
(445)

Fig. 308.



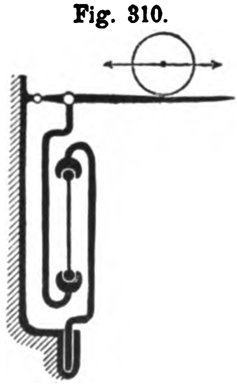
(445)

Fig 309.



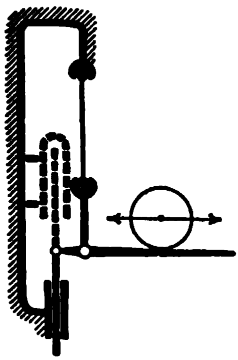
(445)

Fig. 310.



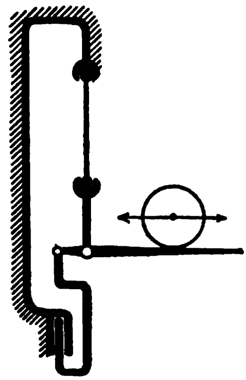
(445)

Fig. 311.



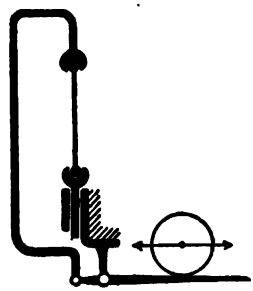
(445)

Fig. 312.



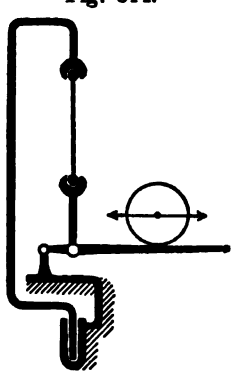
(445)

Fig. 313.



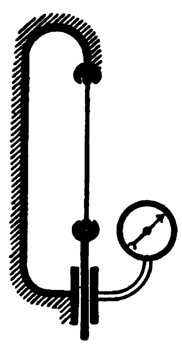
(445)

Fig. 314.



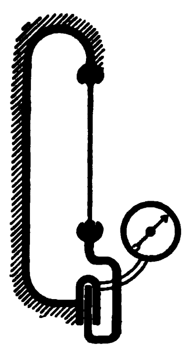
(445)

Fig. 315.



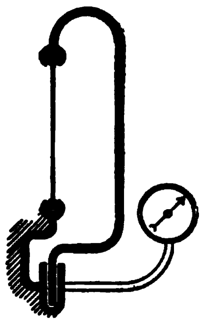
(445)

Fig. 316.



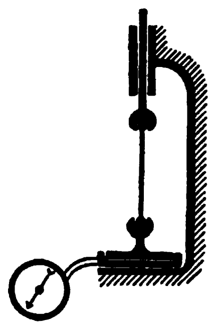
(445)

Fig. 317.



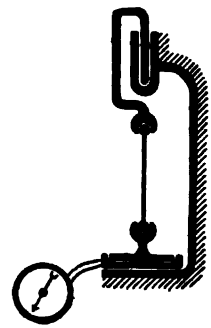
(445)

Fig. 318.



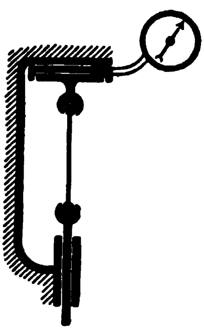
(445)

Fig. 319.



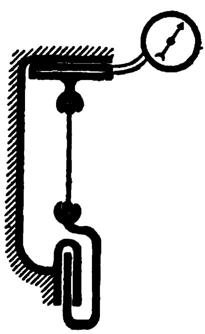
(445)

Fig. 320.



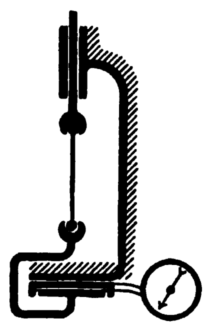
(445)

Fig. 321.



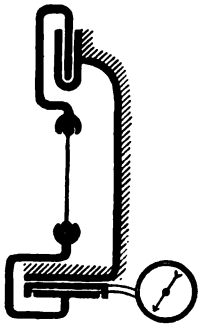
(445)

Fig. 322.



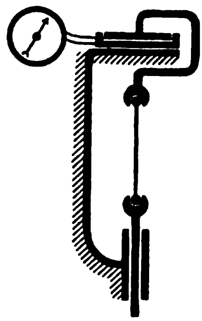
(445)

Fig. 323.



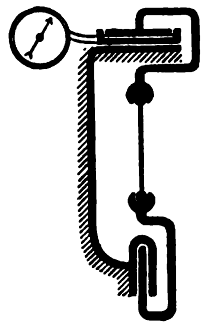
(445)

Fig. 324.



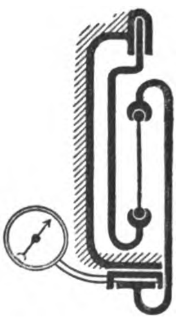
(445)

Fig. 325.



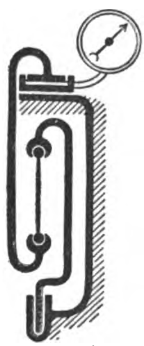
(445)

Fig. 326.



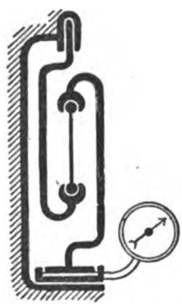
(445)

Fig. 327.



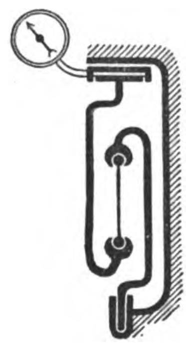
(445)

Fig. 328.



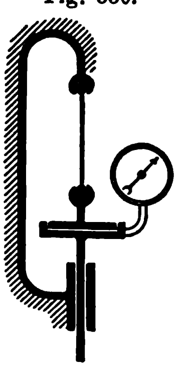
(445)

Fig. 329.



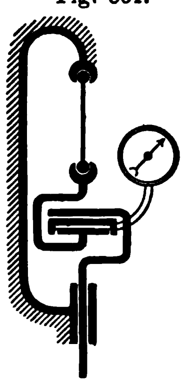
(445)

Fig. 330.



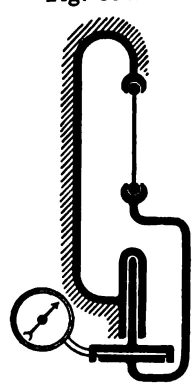
(445)

Fig. 331.



(445)

Fig. 332.



(445)

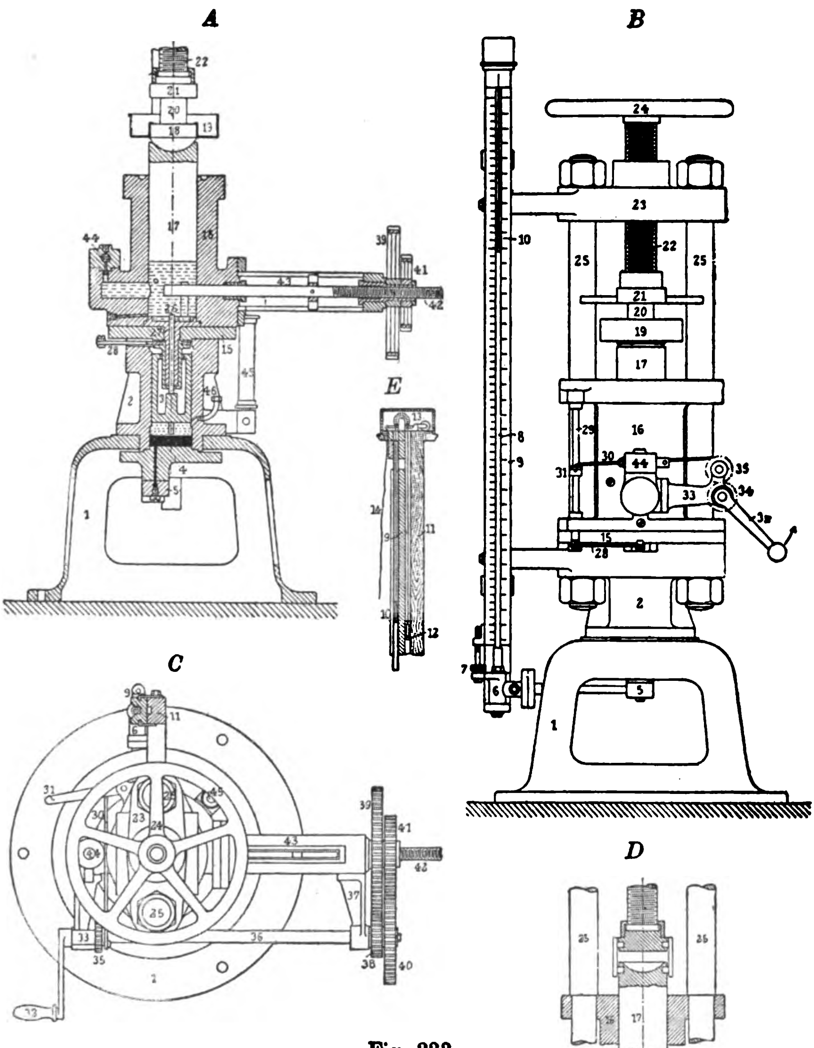


Fig. 333.

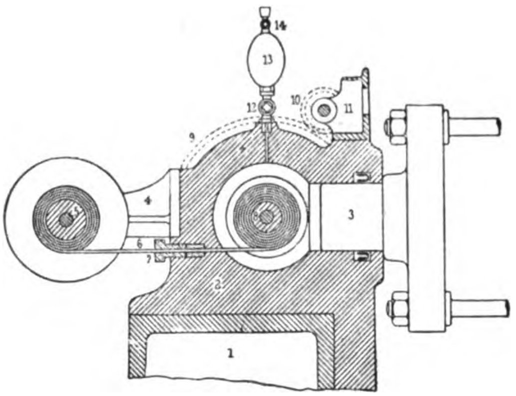


FIG. 334. (455)

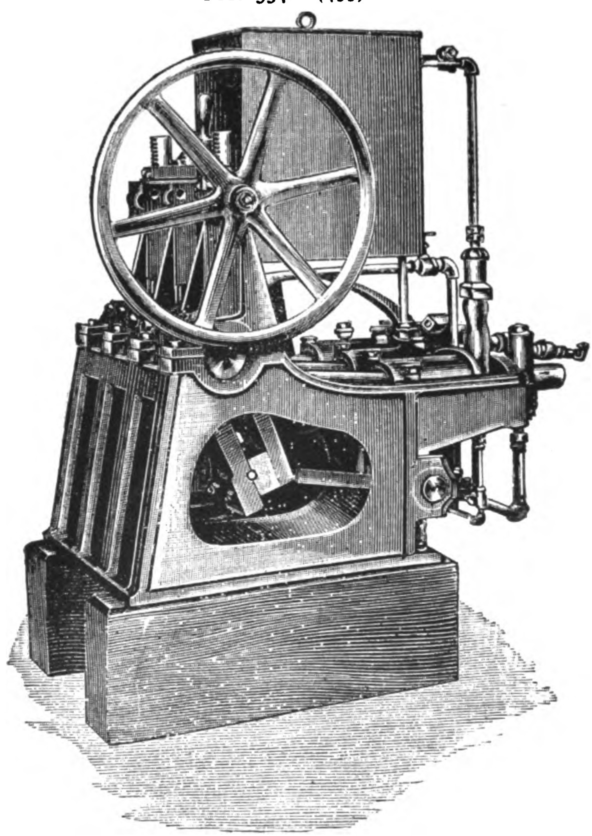


Fig. 335.
(459)

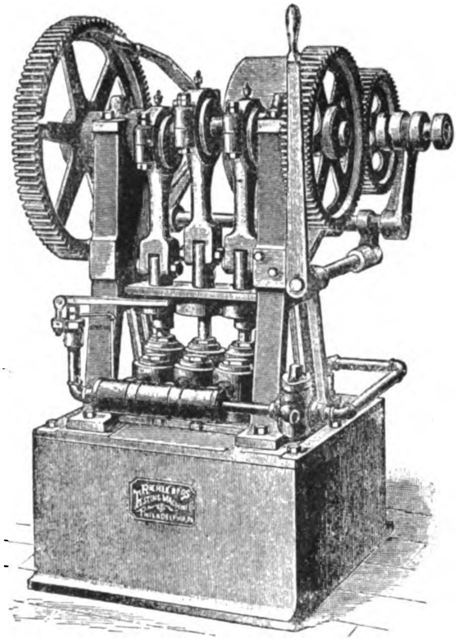


Fig. 336.
(460)

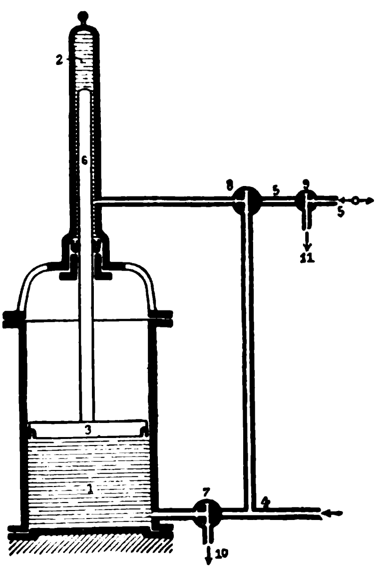


Fig. 337.
(464)

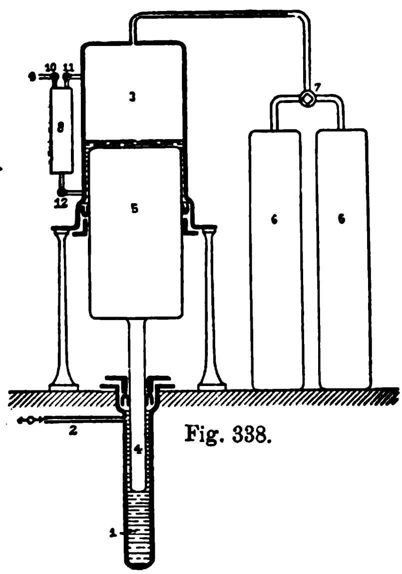


Fig. 338.
(466)

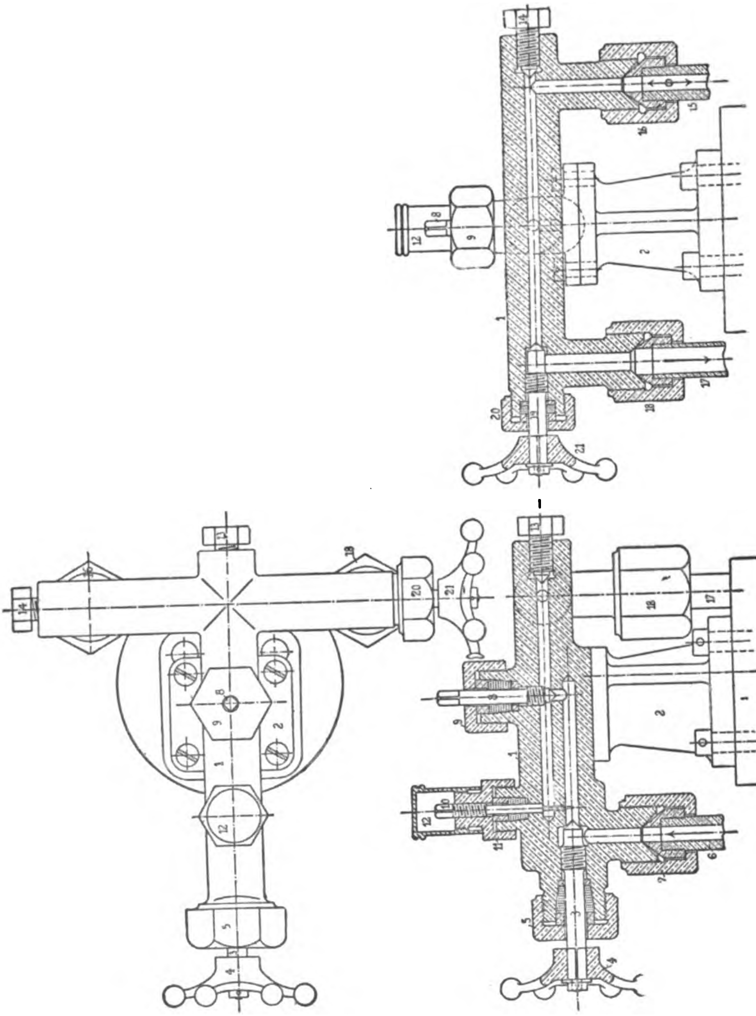


FIG. 339. (469)

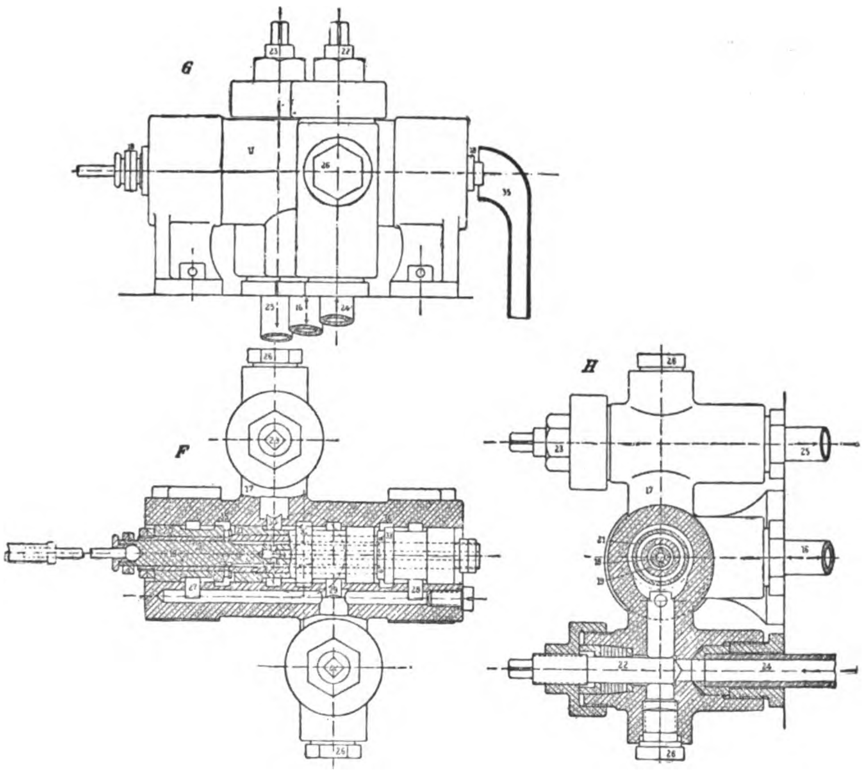


FIG. 340. (471)

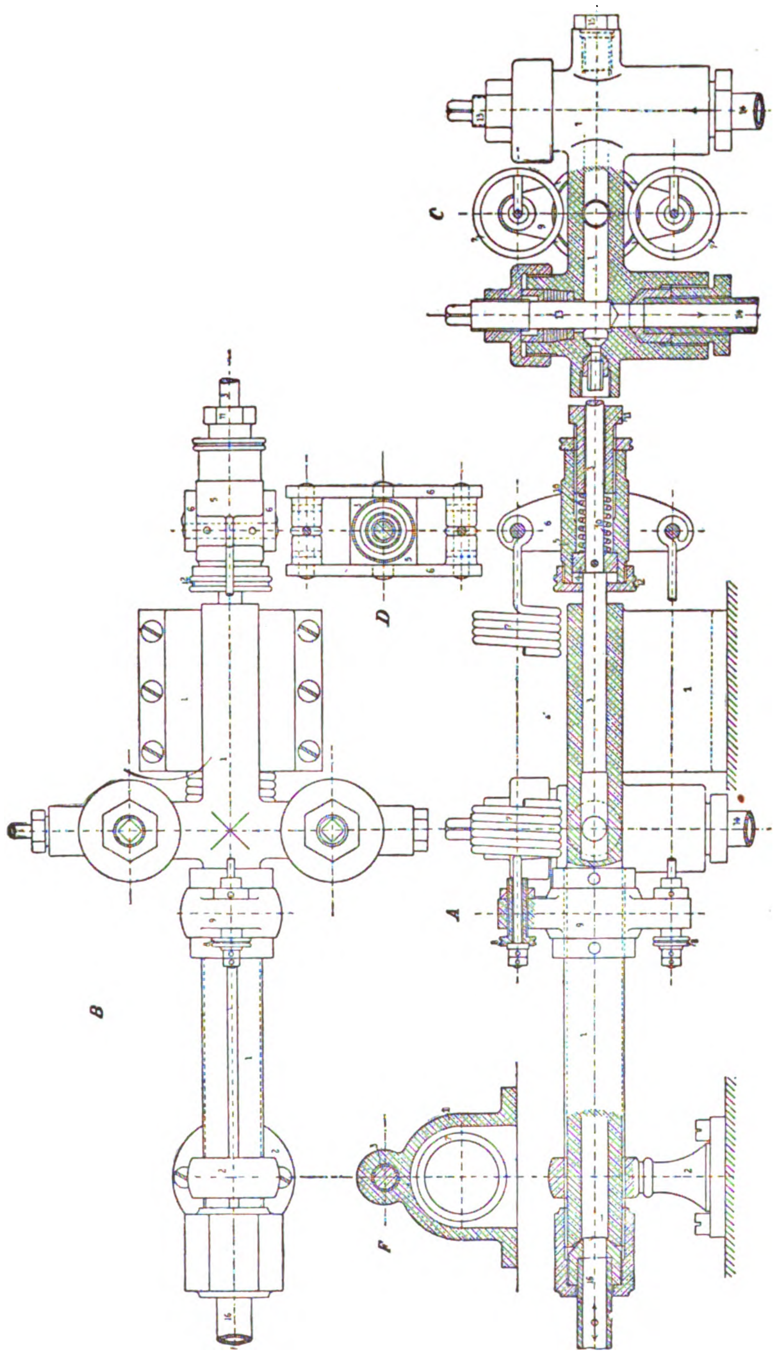


Fig. 340a. (471)

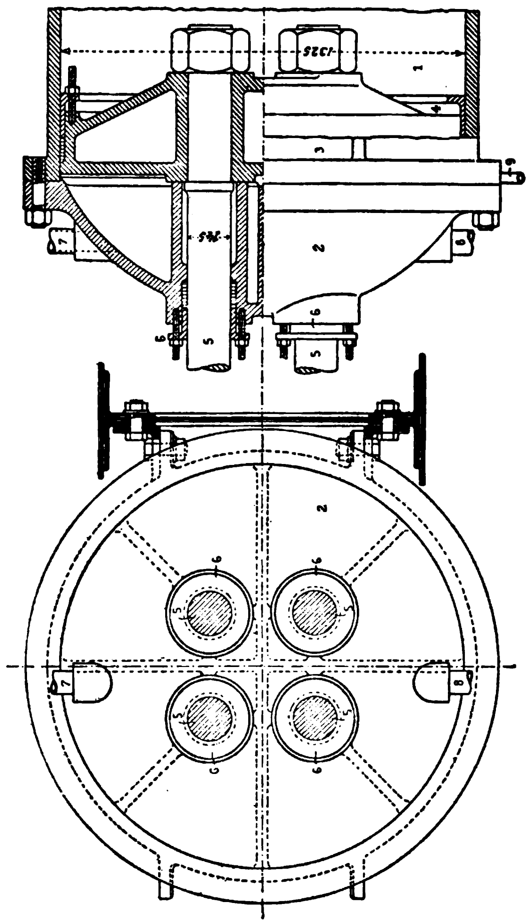


Fig. 341.
(475)

Frictional Resistance of Cupped-leather Packing in Hydraulic Presses.

(Trans. Am. Soc. C. E. 1887, p. 30.)

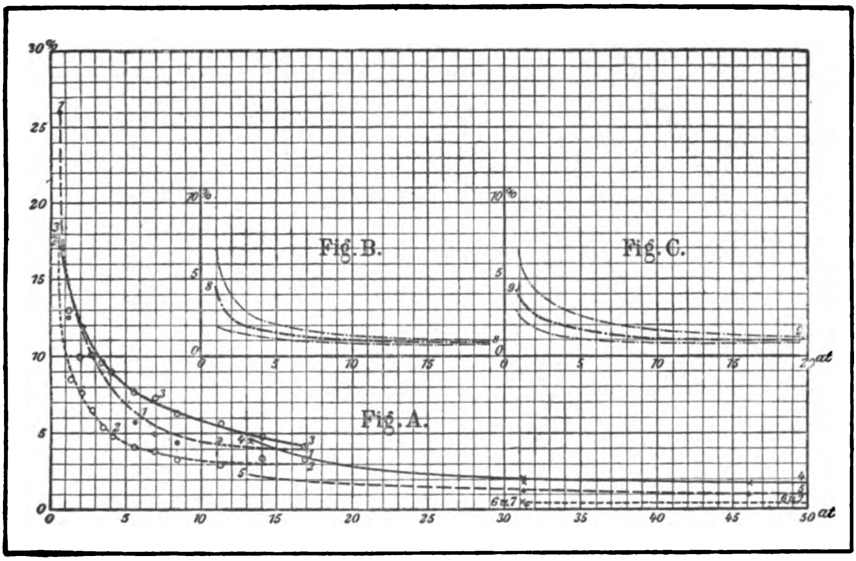


FIG. 342. (476)

1 to 3. Diam. of piston ½″ (= 12.7 mm.): 1, new stiff leather; 2, well-worn; 3. new leather. [lubricated.
4 & 5 " " " 4″ (= 102 mm.); 4, " " " ; moderately greased; 5, well treated and well
6 & 7 " " " 8″ (= 203 mm.); 6, " " " ; " " ; 7. " " " "
8 " " " 9″ (= 230 mm.); 8. 16 series of tests with cup leathers of different widths.
9 " " " 6″ (= 150 mm.); 9. 24 " " " " " " " " "

In 8 and 9 averages = heavy lines; maxima and minama = light lines.

Nos. 1–7 Tests by Hicks; Nos. 8 and 9, Flad's Tests.

In case of 4–7 the friction decreases constantly under increasing pressures, and becomes less than 0.5% for U = 400 at. (about 6000 lbs. per sq. in.).

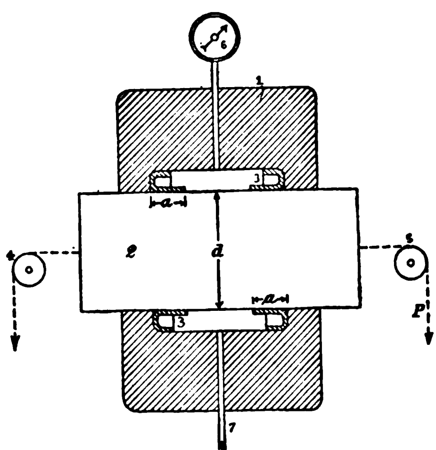


FIG. 343. (476)

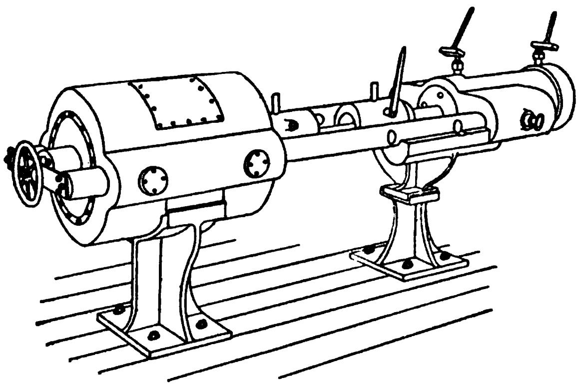


Fig. 344.
(483)

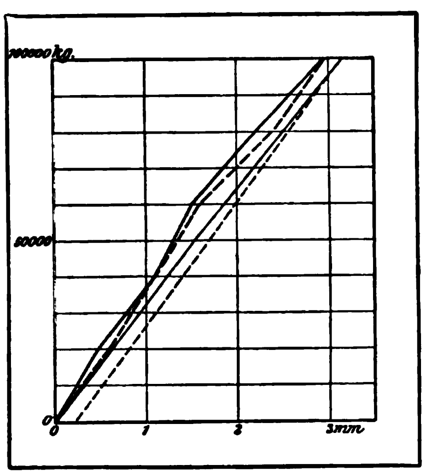


FIG. 345. (483)

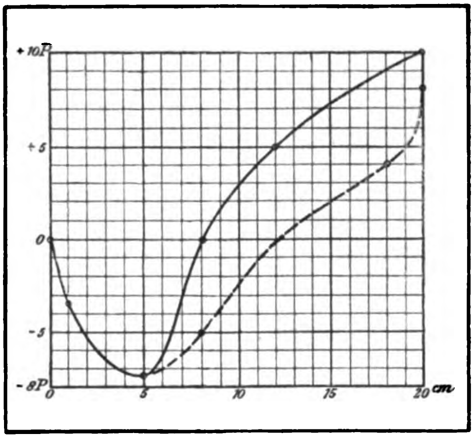


FIG. 346. (483)

Equilibrium of Beam at o for different positions of piston.
——— advancing piston ; — — — — — — receding piston.

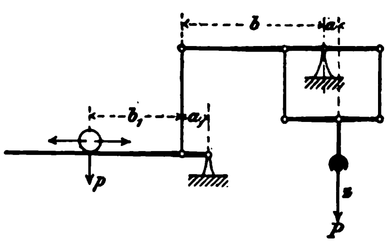


FIG. 347. (492)

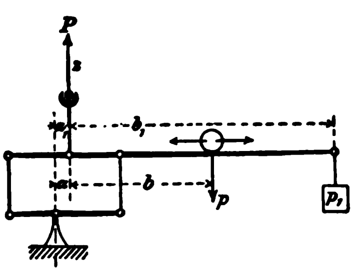


FIG. 348. (492)

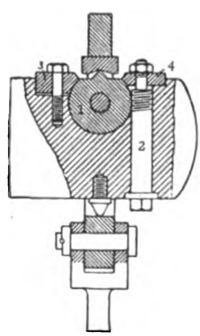


FIG. 349. (496)

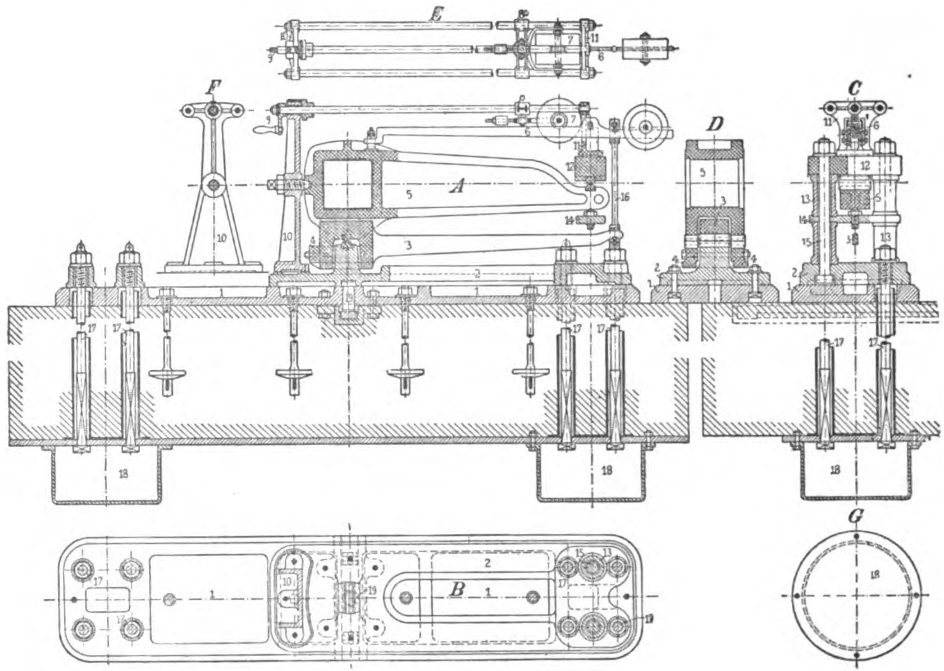


Fig. 350. (500

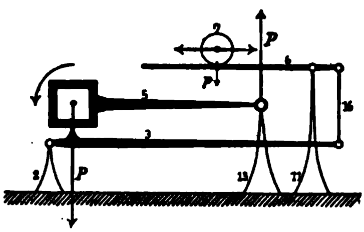


FIG. 351.
(500)

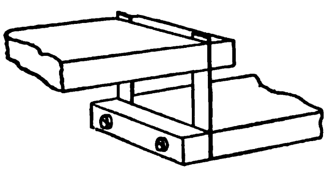


Fig. 352.
502)

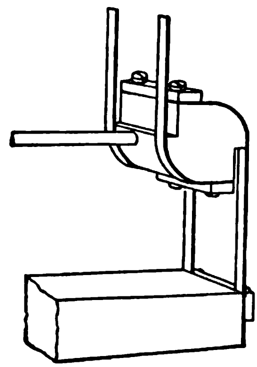


Fig. 353.
(502)

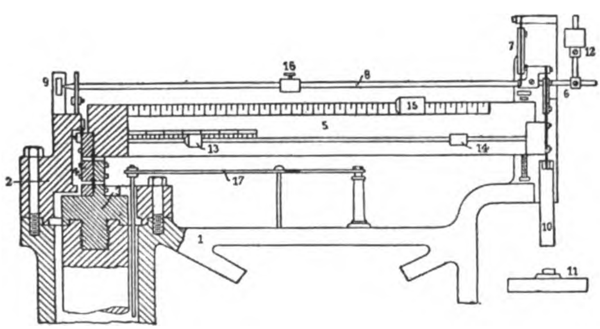


Fig. 354.
(502)

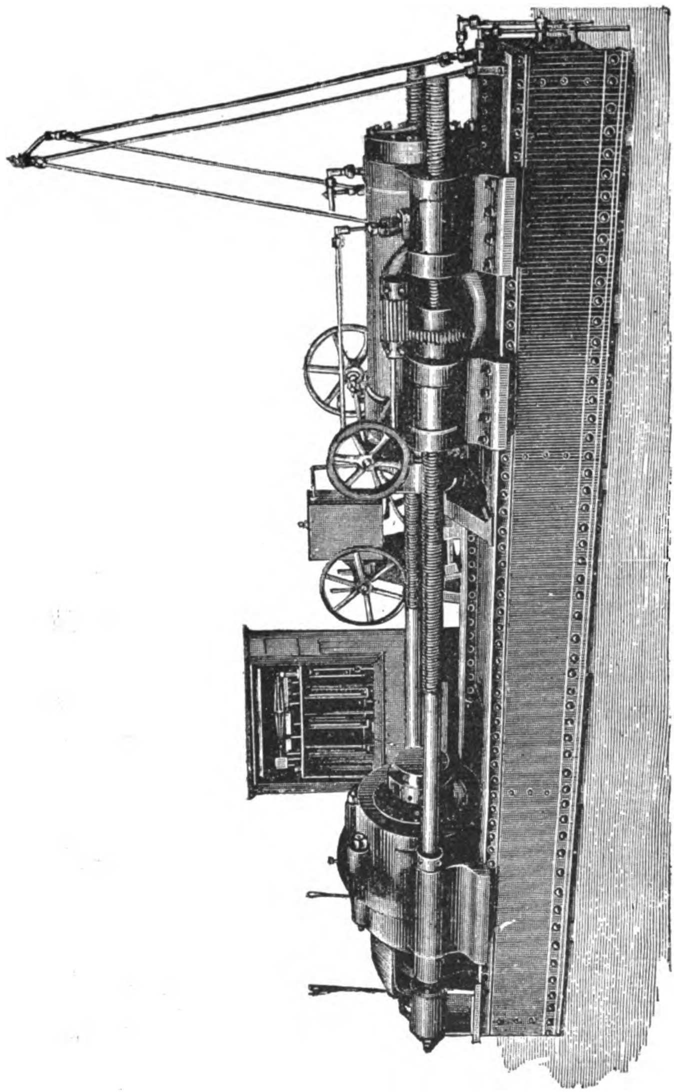


Fig. 356.
(504)

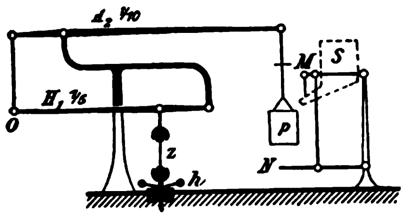
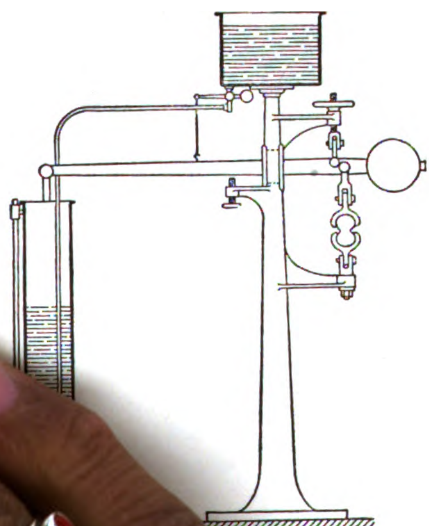


Fig. 357.

(509)



58.

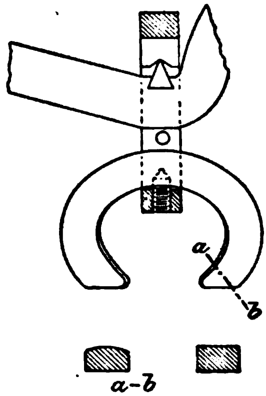


Fig. 359.
(509)

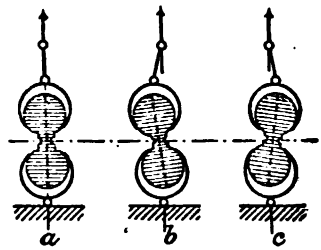


Fig. 360.
(509)

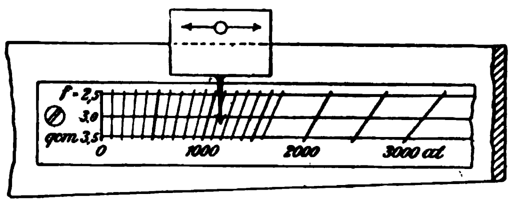


Fig. 361. (514)

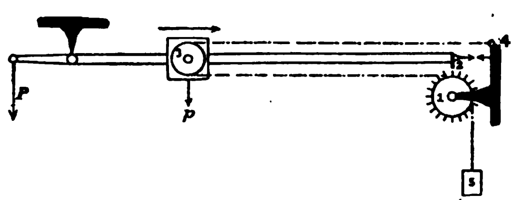


Fig. 362.
(522)

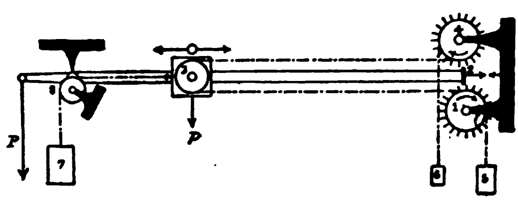


Fig. 363.
(522)

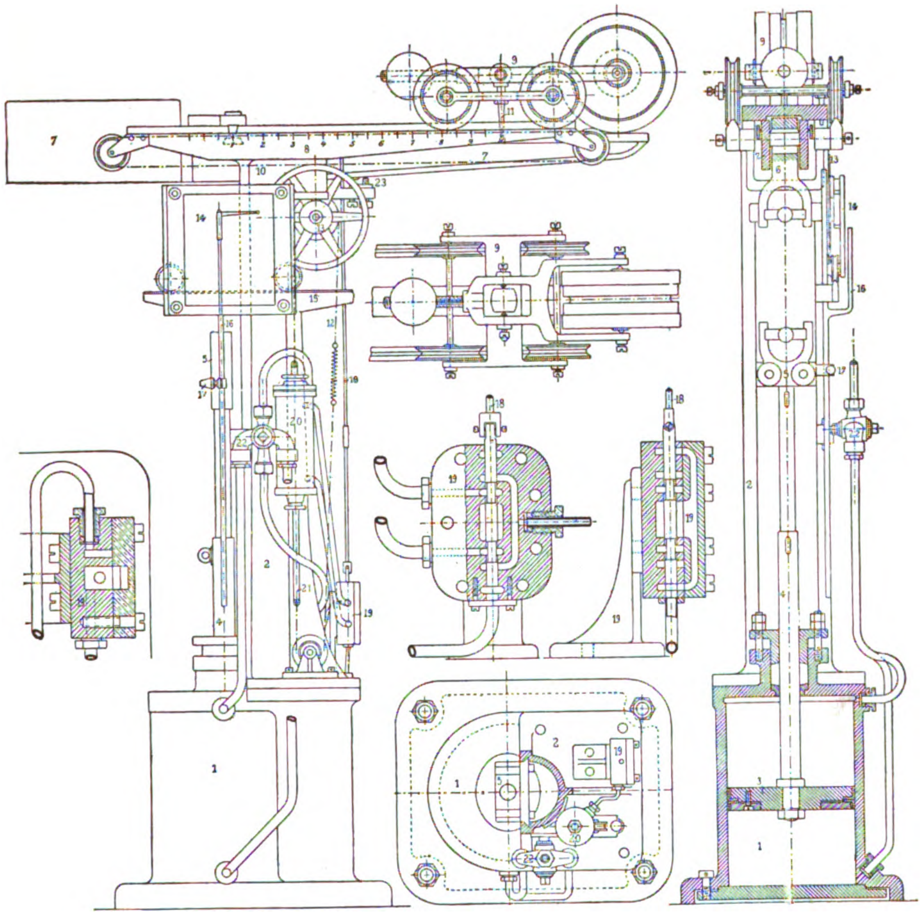


FIG. 364. (524)

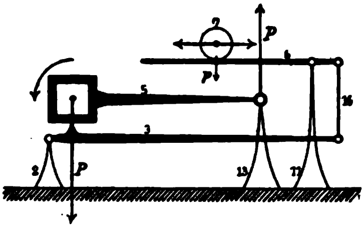


FIG. 351.
(500)

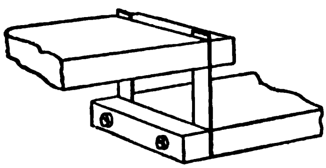


Fig. 352.
502)

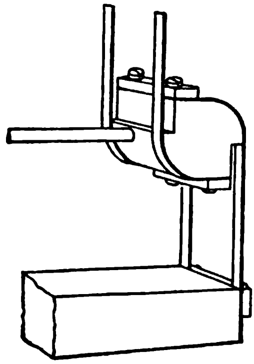


Fig. 353.
(502)

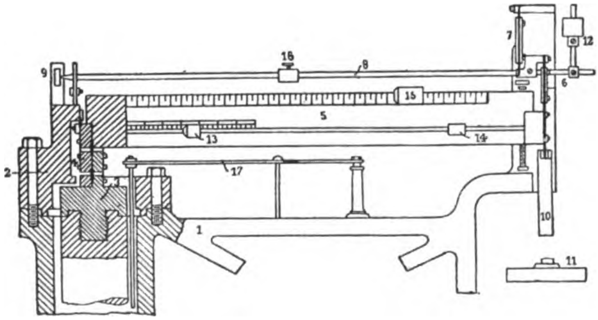


Fig. 354.
(502)

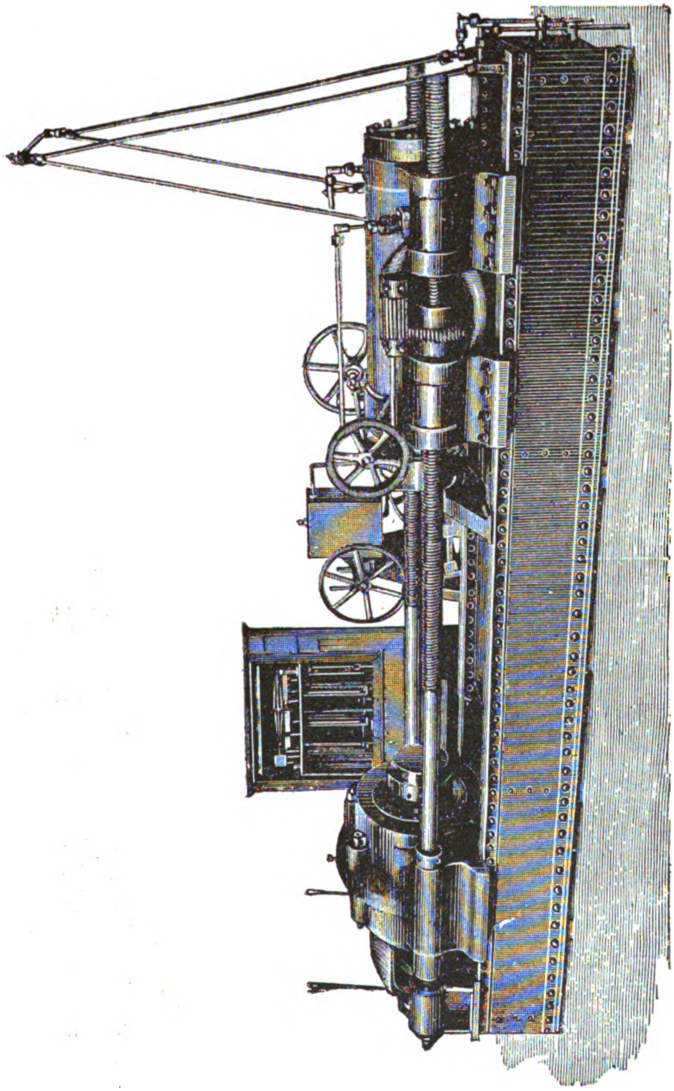


Fig. 356.
(504)

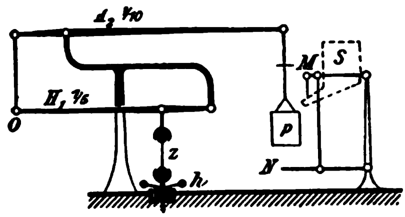


Fig. 357.

(509)

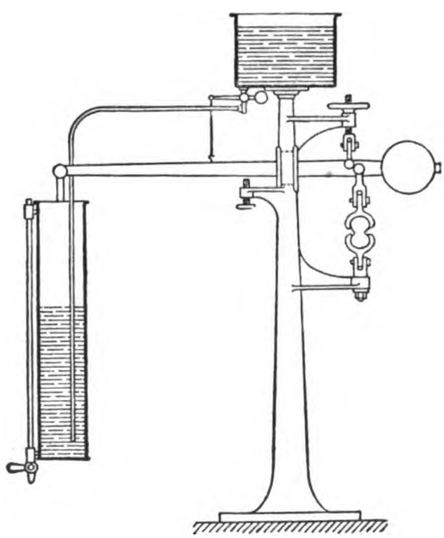


Fig. 358.

(509)

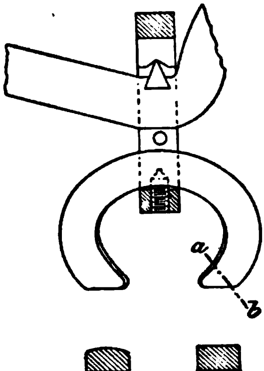


Fig. 359.
(509)

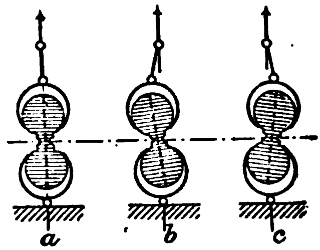


Fig. 360.
(509)

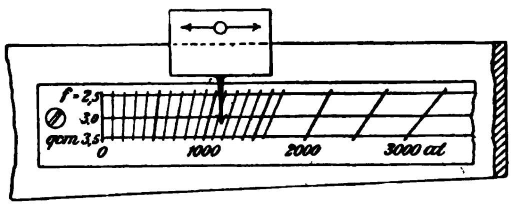


Fig. 361. (514)

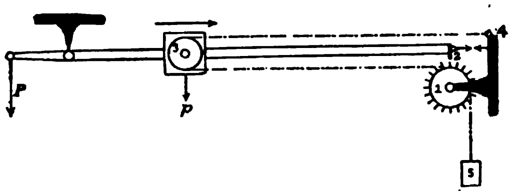


Fig. 362.
(522)

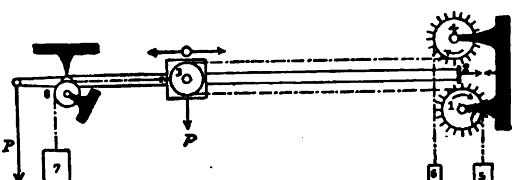


Fig. 363.
(522)

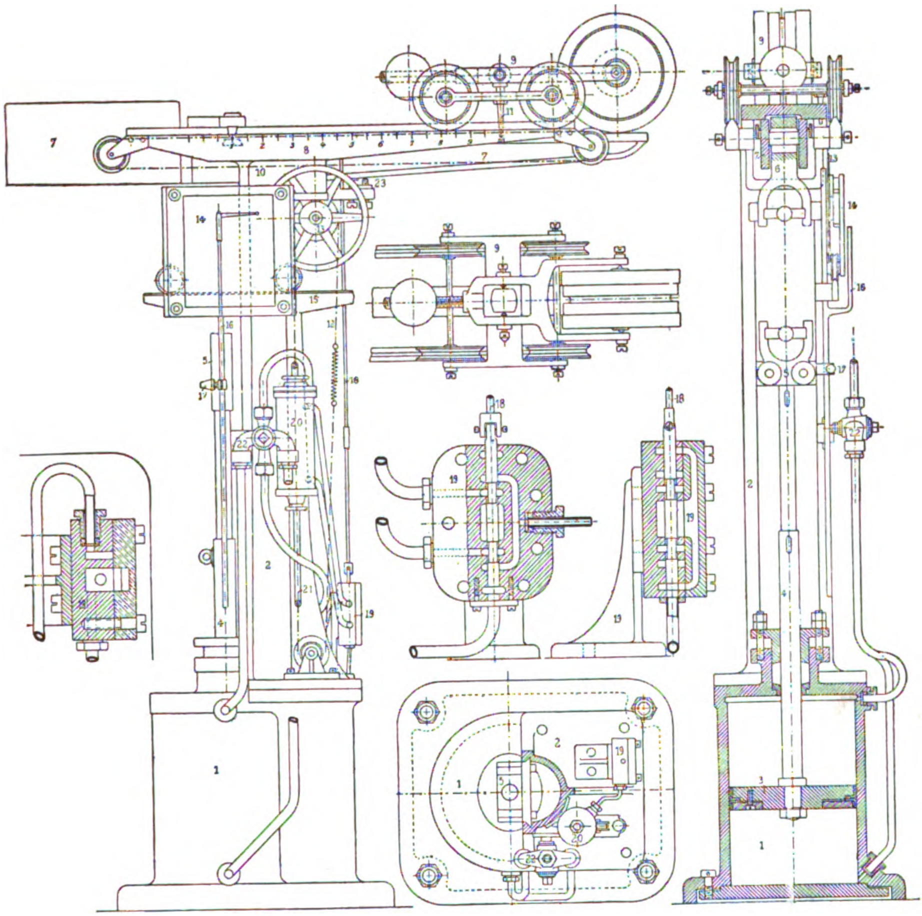


FIG. 364. (524)

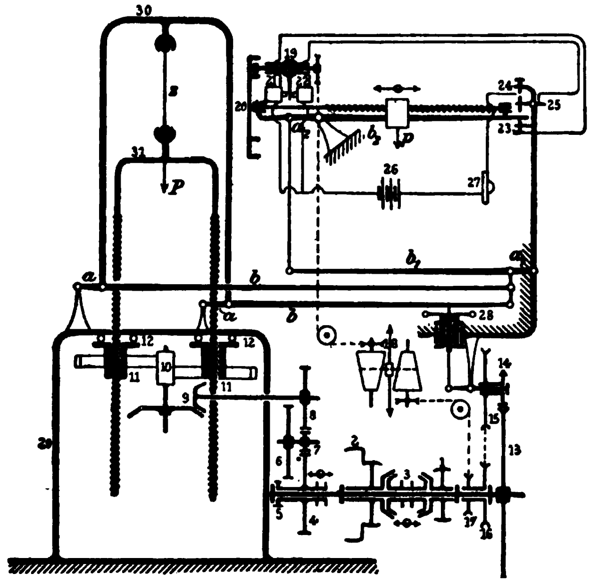


FIG. 365. (525)

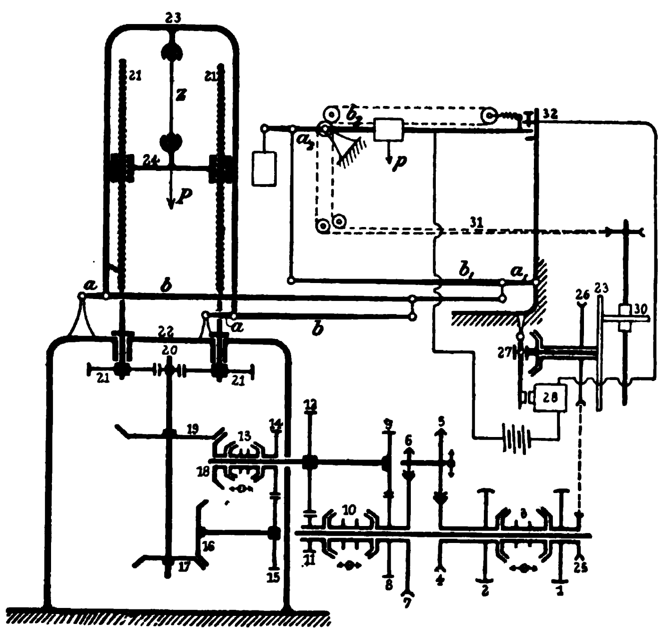


FIG. 366. (526)

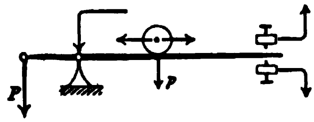


FIG. 367. (529)

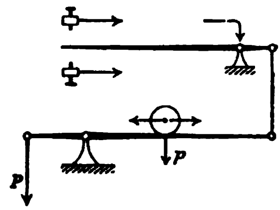


FIG. 368. (529)

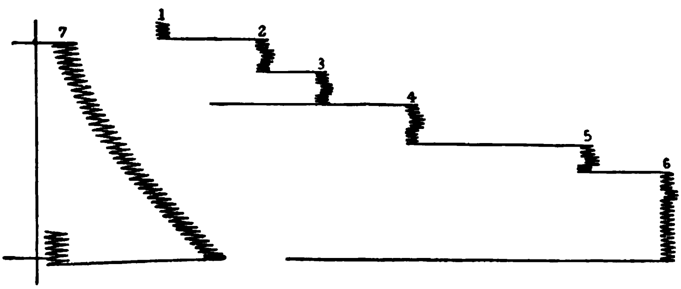


FIG. 369. (530)

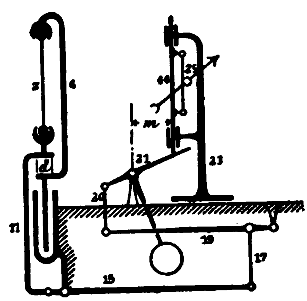


FIG. 370. (532)

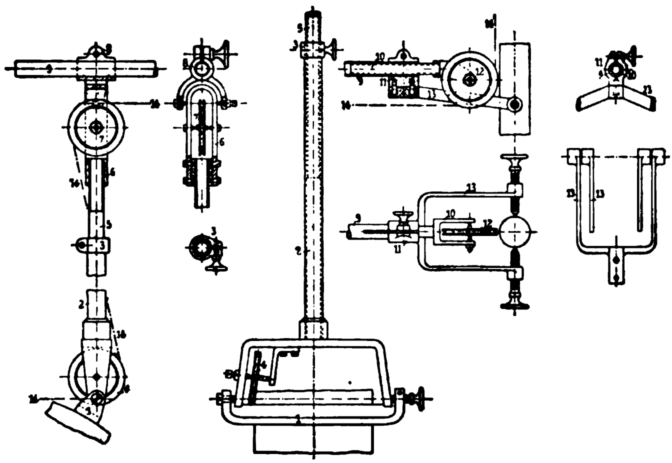


FIG. 371. (534)

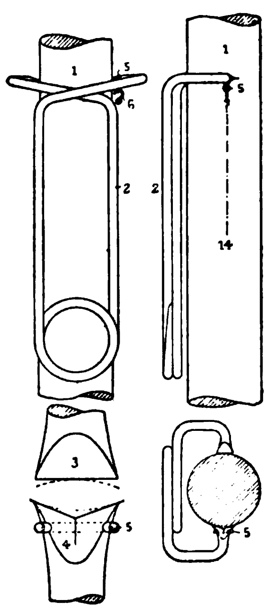


Fig. 372.

(534)

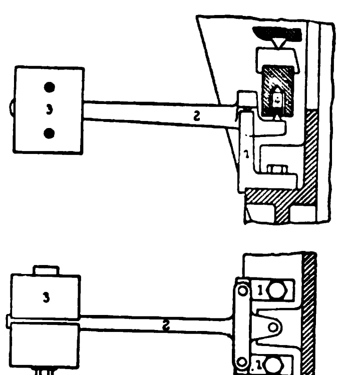


FIG. 373.

(534)

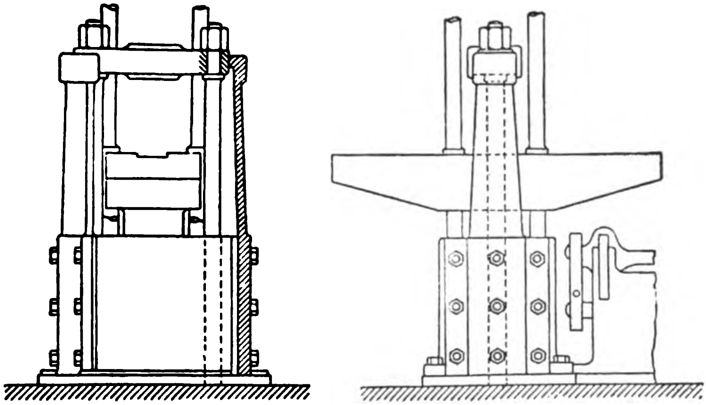


Fig. 374.

(534)

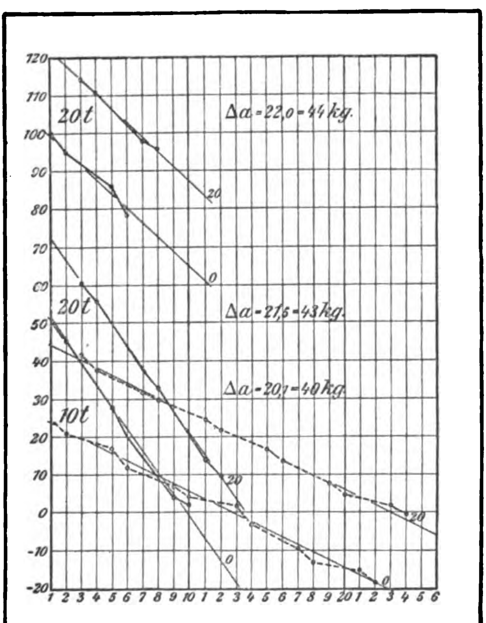


FIG. 375.

(534)

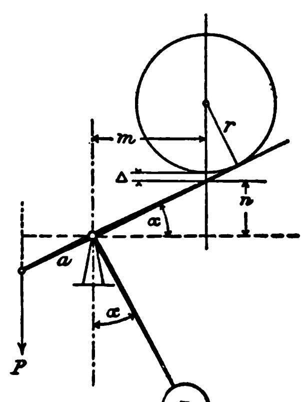


Fig. 376

(534)

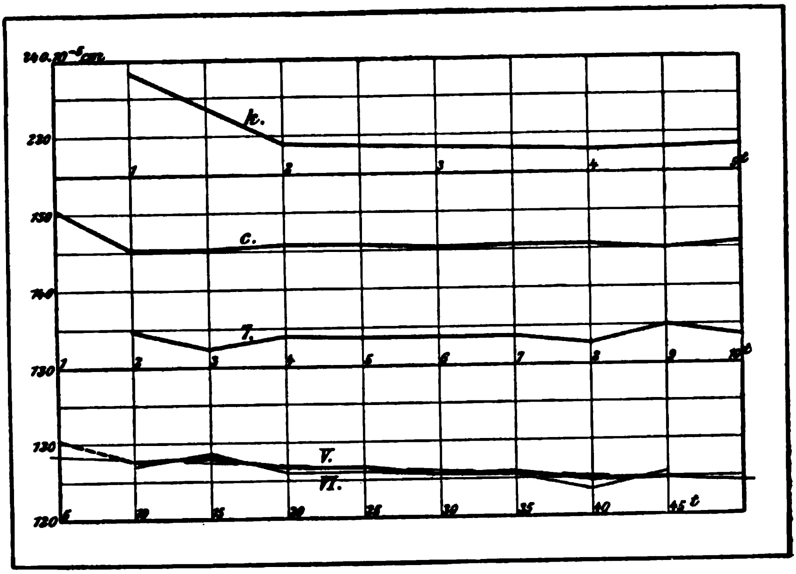


FIG. 377. (534)

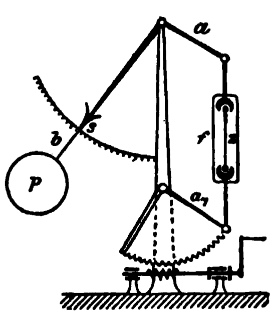


Fig. 379.
(535)

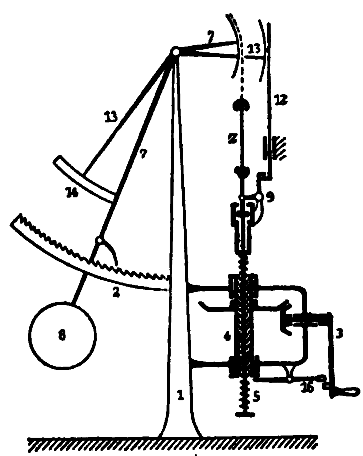
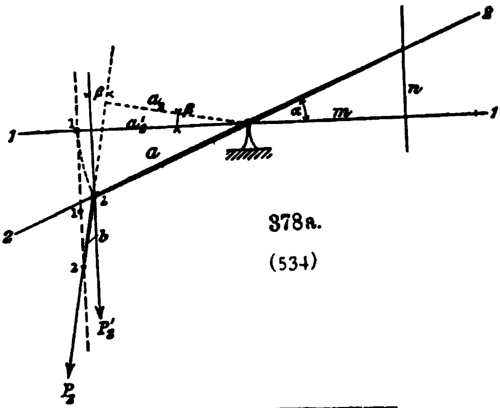


Fig. 380.
(535)



378a.

(534)

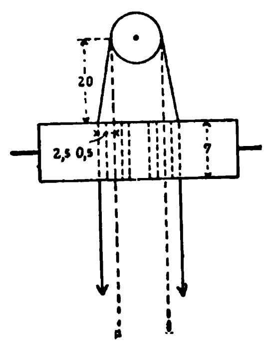


Fig. 378b. (534)

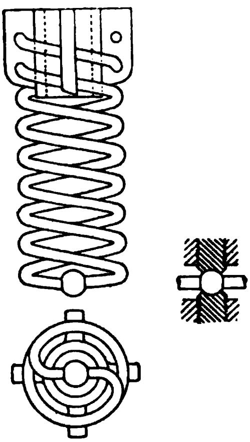


Fig. 381. (531)

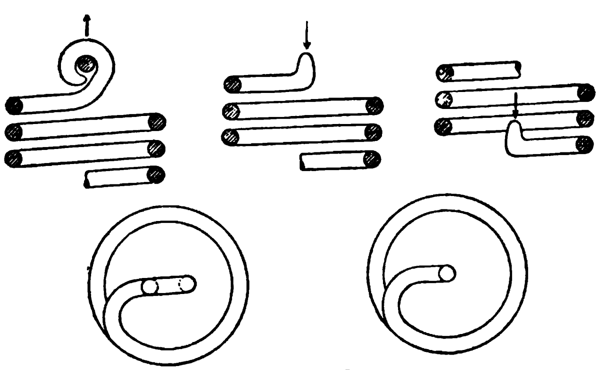


Fig. 382.

(541)

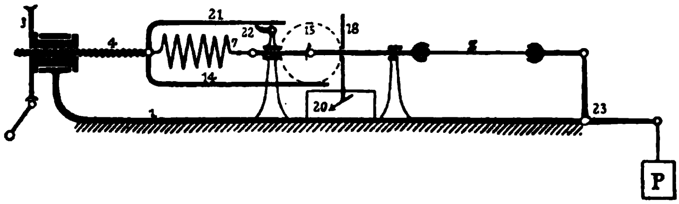


FIG. 383. (542)

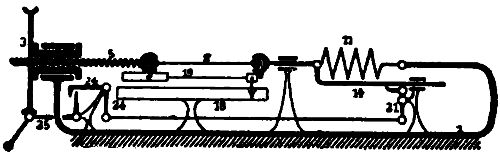


FIG. 384. (543)

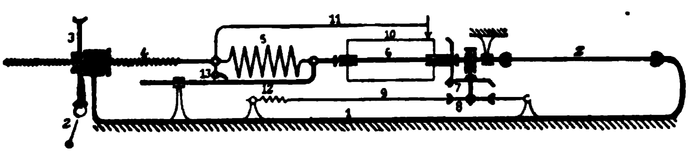


Fig. 385.
(545)

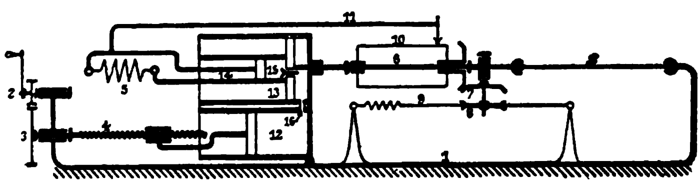


Fig. 386.
(546)

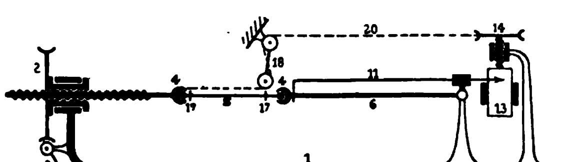


FIG. 387. (546)

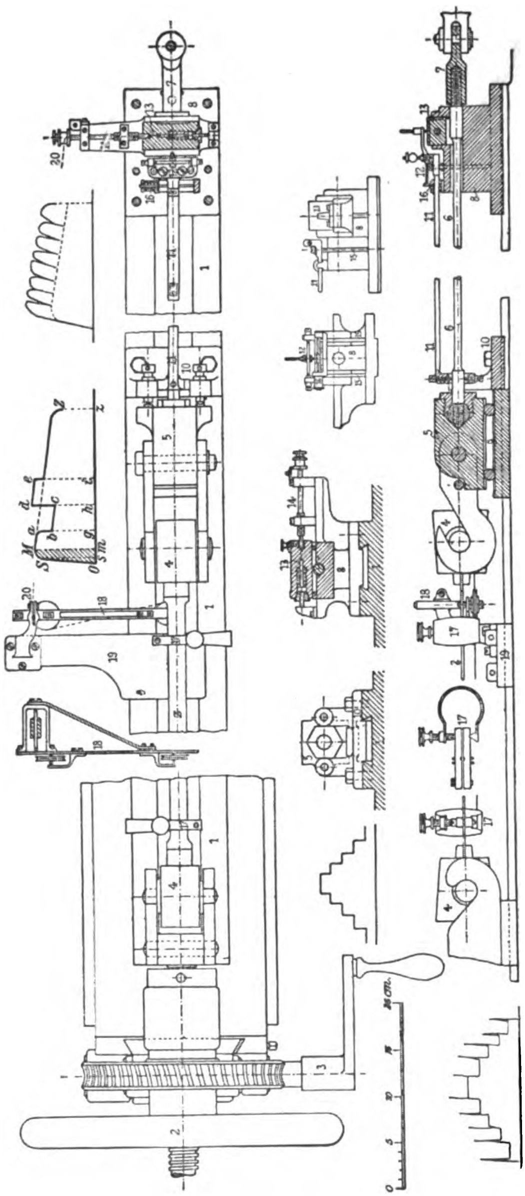


Fig. 388. (546)

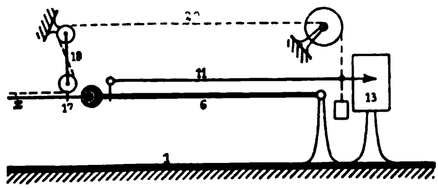


FIG. 389. (547)

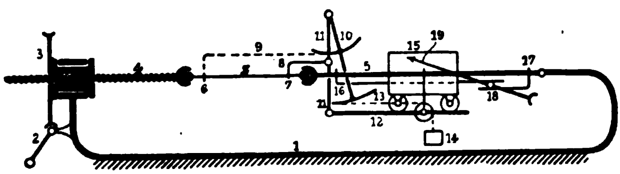


FIG. 390. (548)

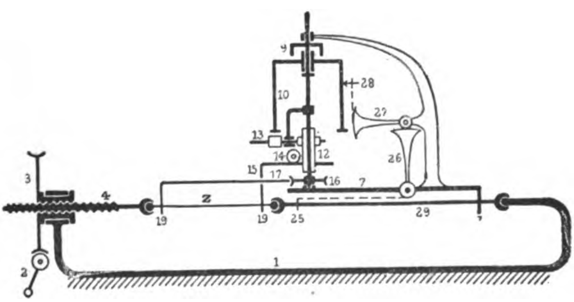


FIG. 391.
(552)

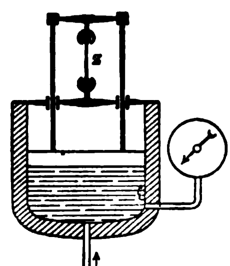


Fig. 391a.
(552)

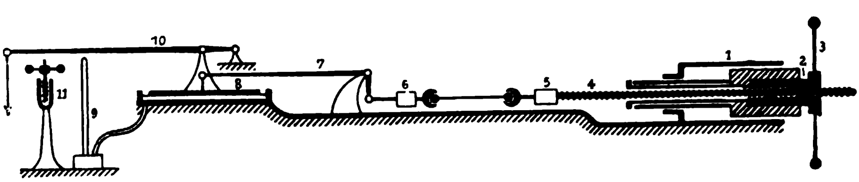


FIG. 392. (554)

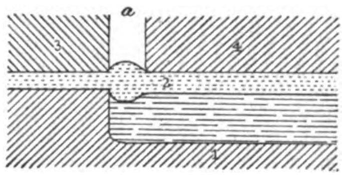


FIG. 393. (556)

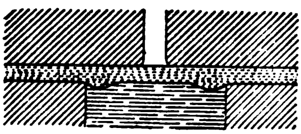


Fig. 394.
(556)

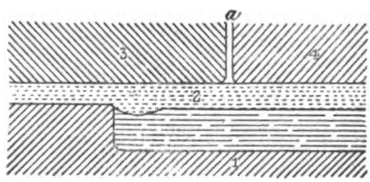


FIG. 394a.
(556)

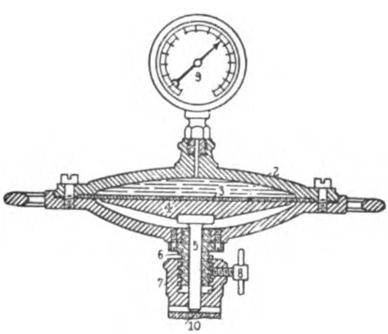


FIG. 395.
(556)

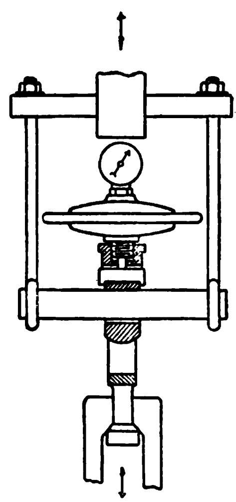


Fig. 396.
(556)

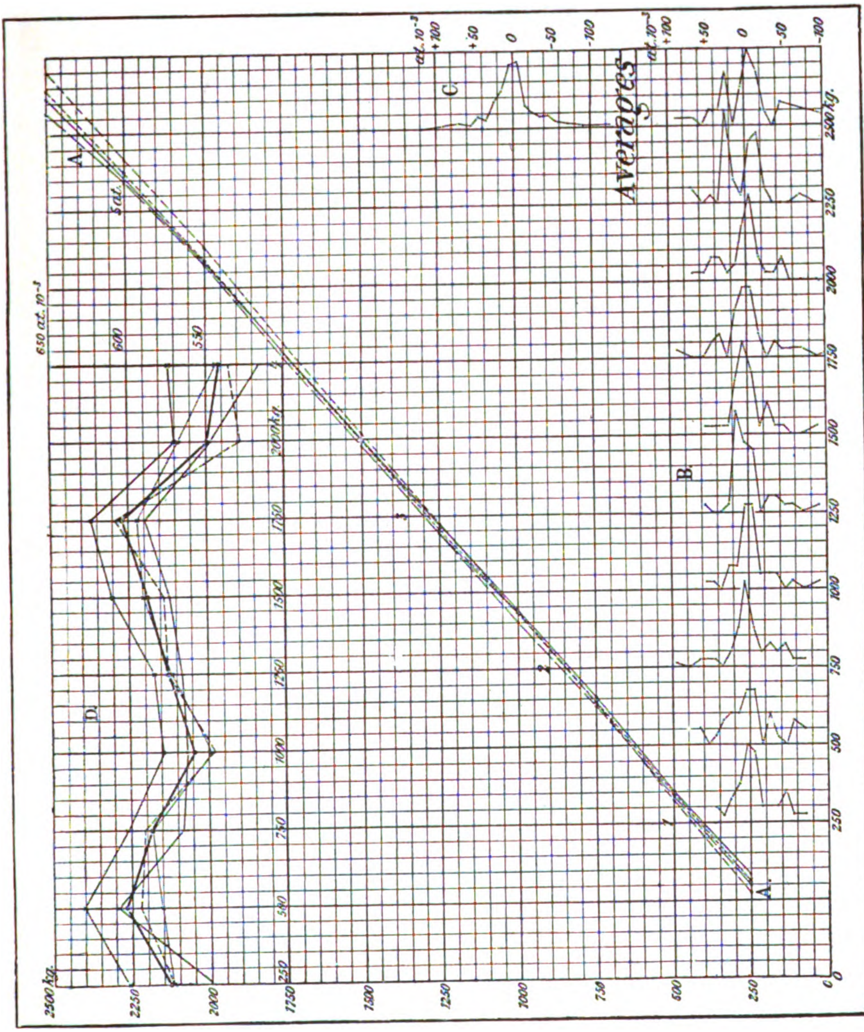


FIG. 397. (556)

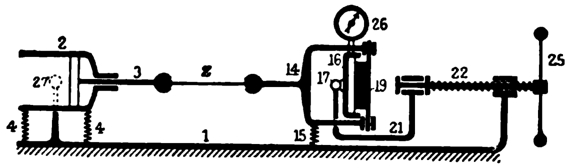


FIG. 398. (557)

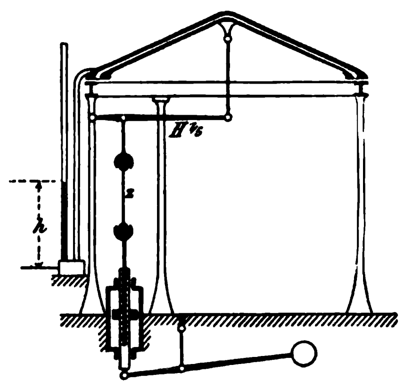


FIG. 399. (558)

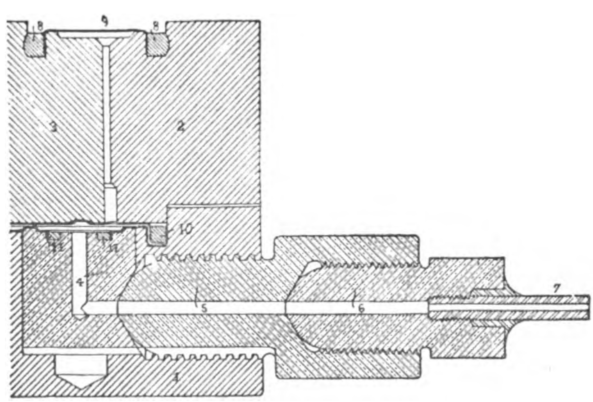


Fig. 401.

(559)

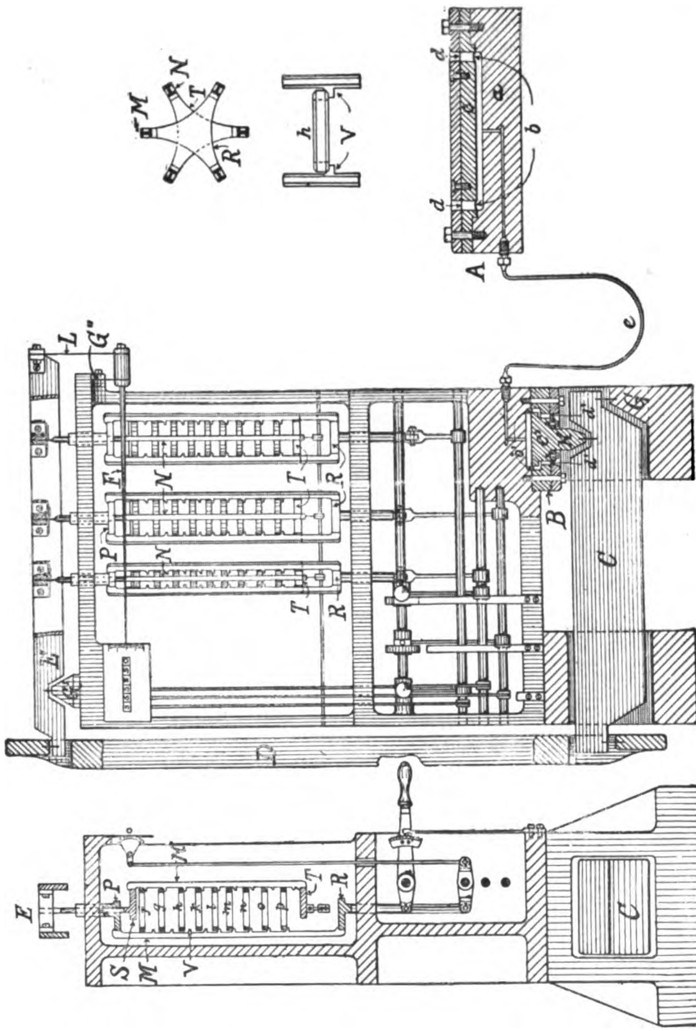


Fig. 400. (559)

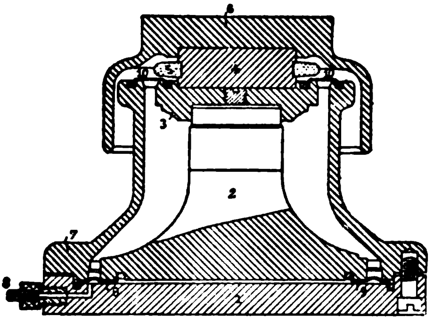


Fig. 402.

(559)

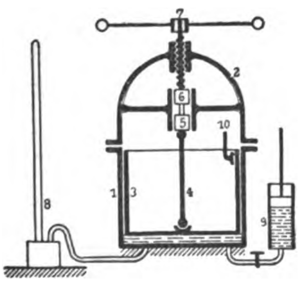


Fig. 403.

(560)

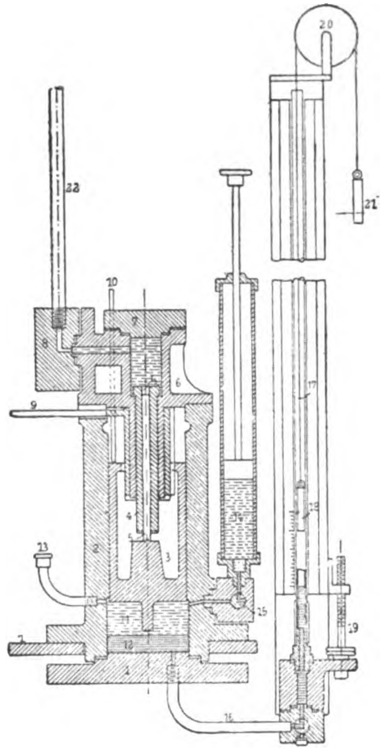


Fig. 404.

(561)

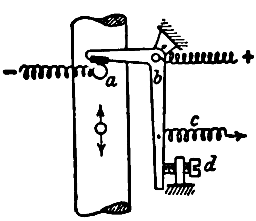


Fig. 405.

(561)

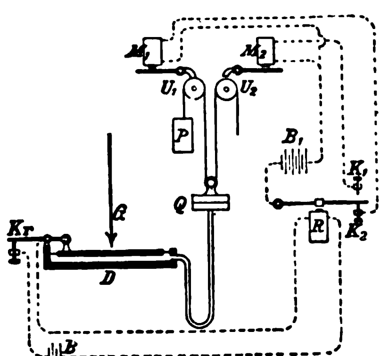


Fig. 406.

(561)

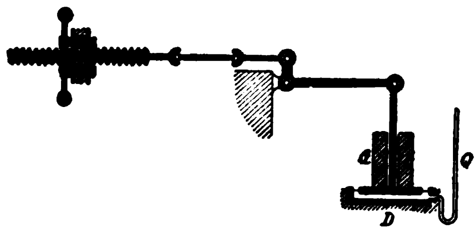


Fig. 407.
(561)

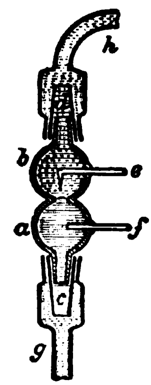


Fig. 409.
(563)

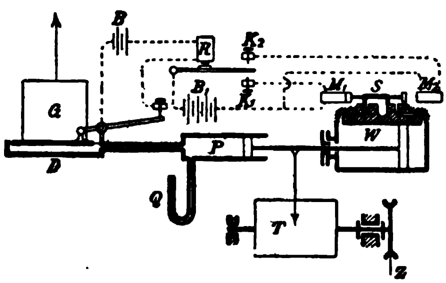


Fig. 408.
(561)

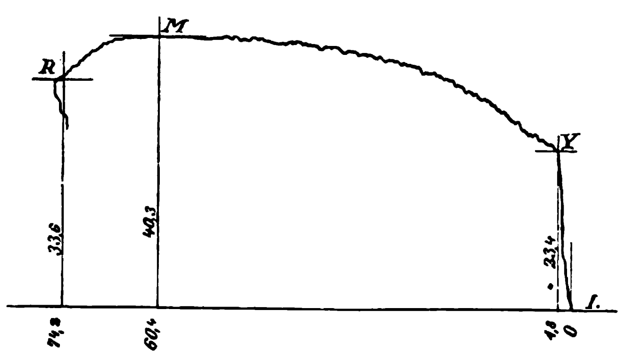


Fig. 410.
(563)

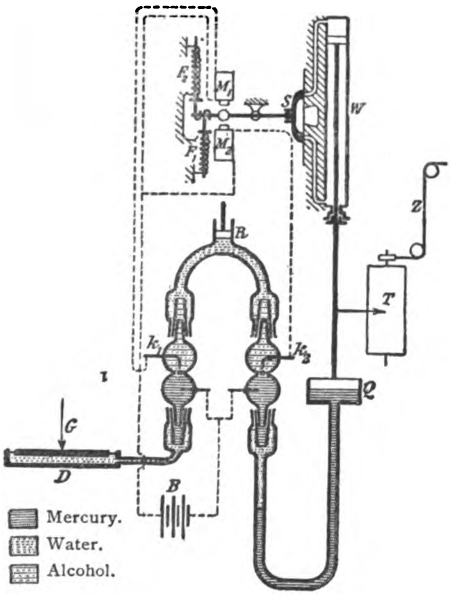


Fig. 411.
(563)

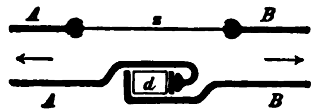


FIG. 412. (568)

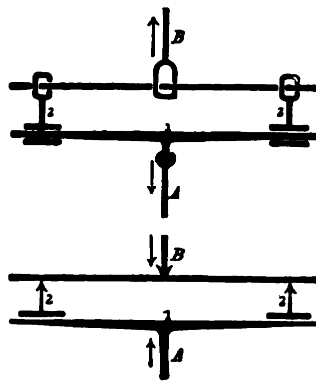


FIG. 413.
(569)

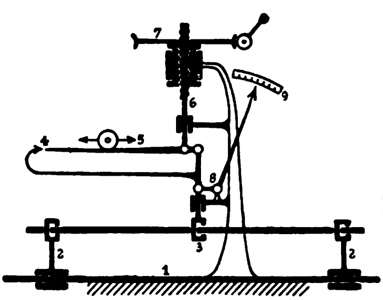


FIG. 414. (576)

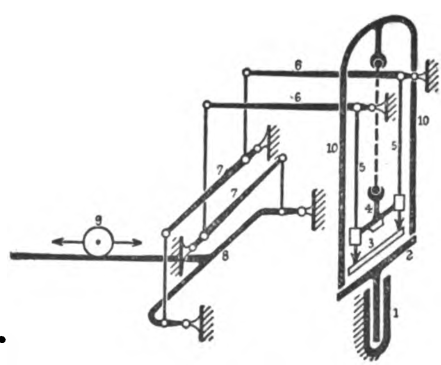


FIG. 415. (583)

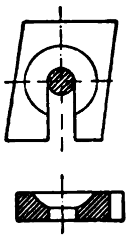


FIG. 416. (588)

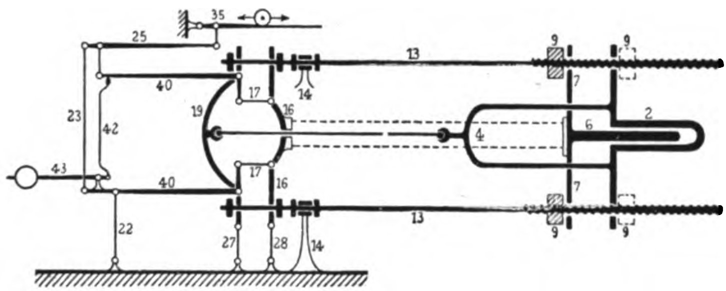


FIG. 417. (591)

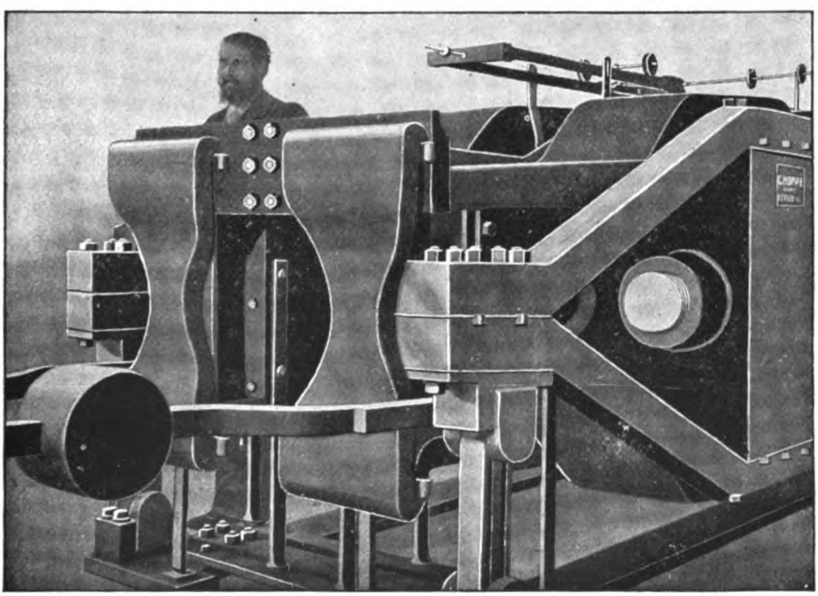


FIG. 417a. (591)

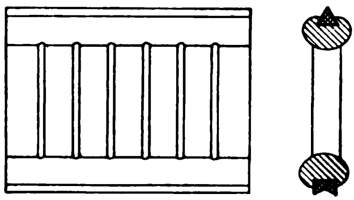


FIG. 418. (595)

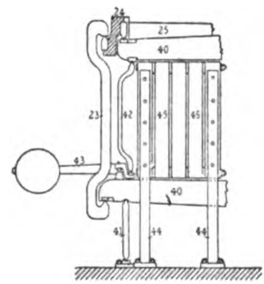


FIG. 419. (595)

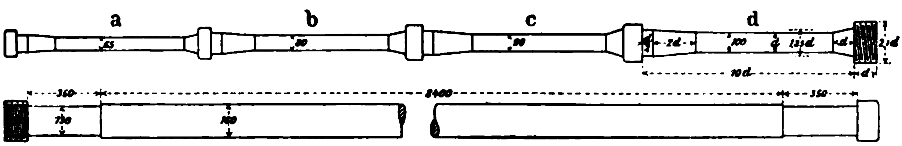


FIG. 420. (595)

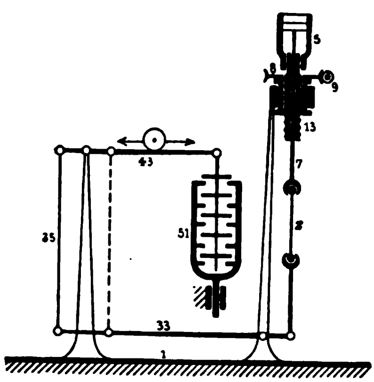


FIG. 421.
(600)

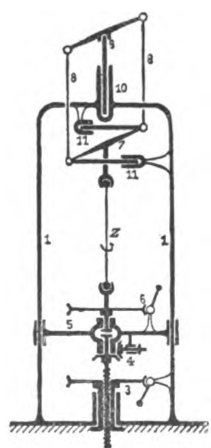


Fig. 422.
(604)

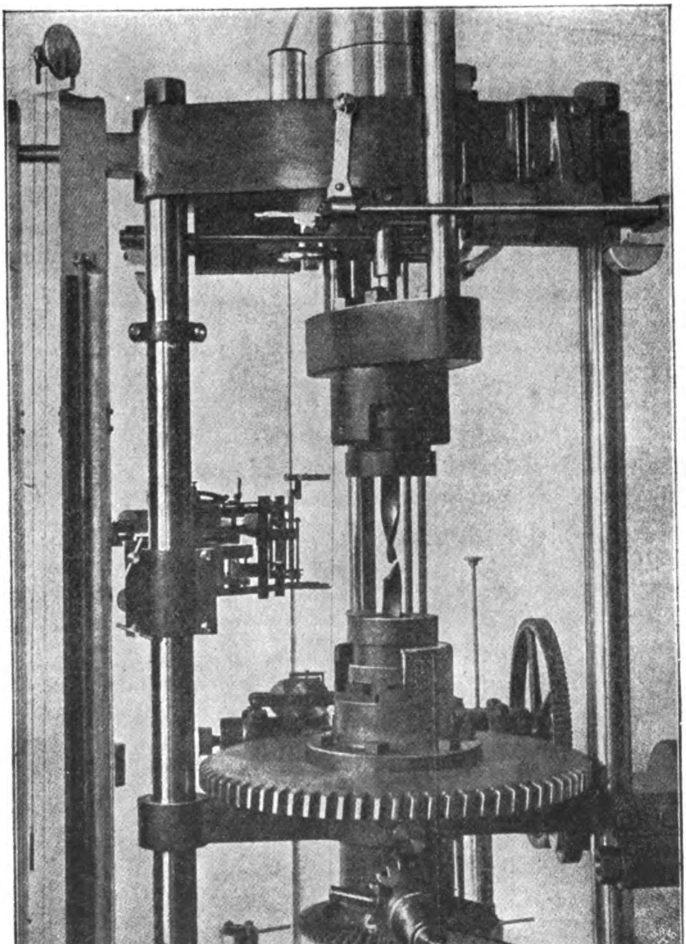


FIG. 423. (604)

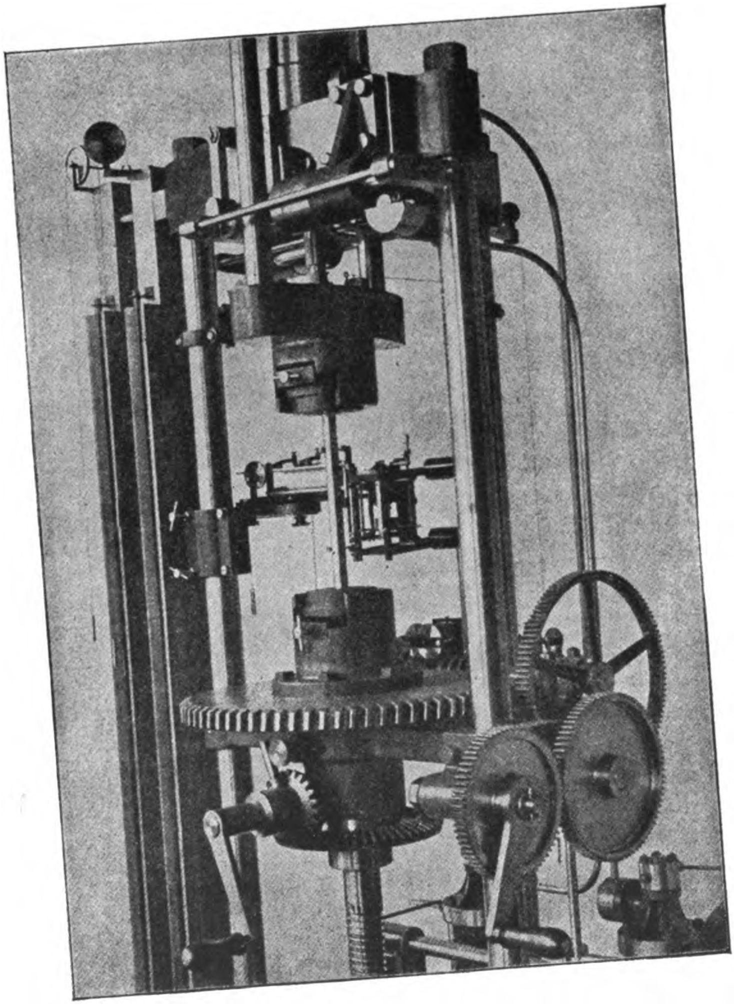


FIG. 424. (604)

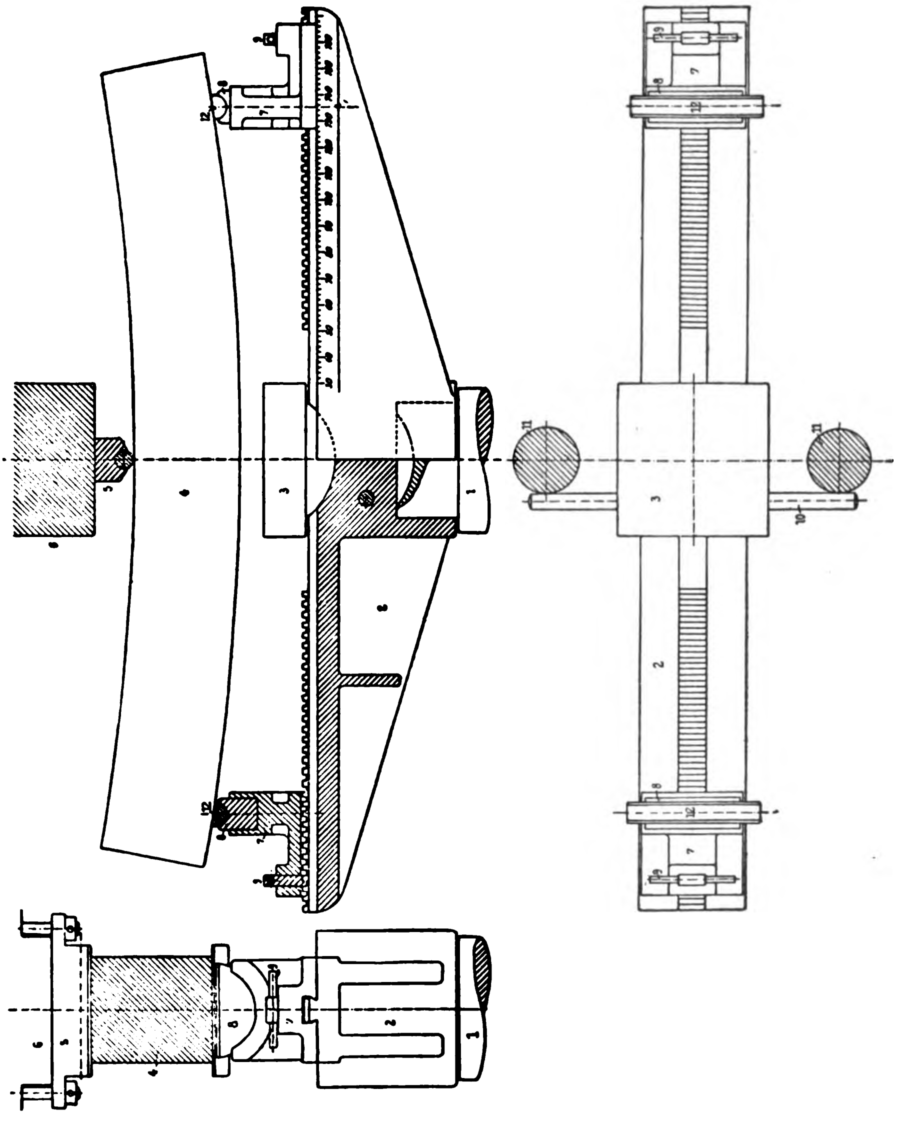


FIG. 425. (609)

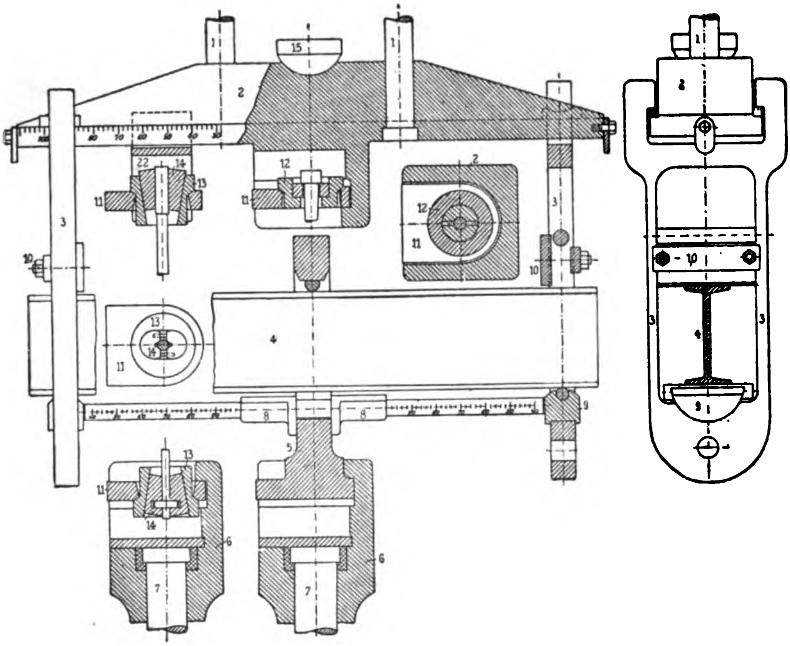


FIG. 426. (609)

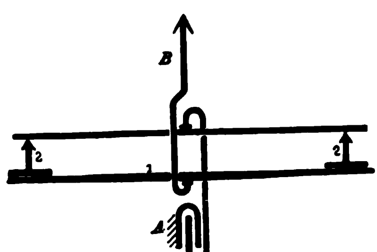


FIG. 427. (615)

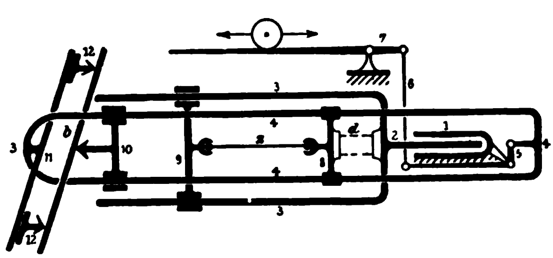


FIG. 428. (616)

Kirkaldy Machine.

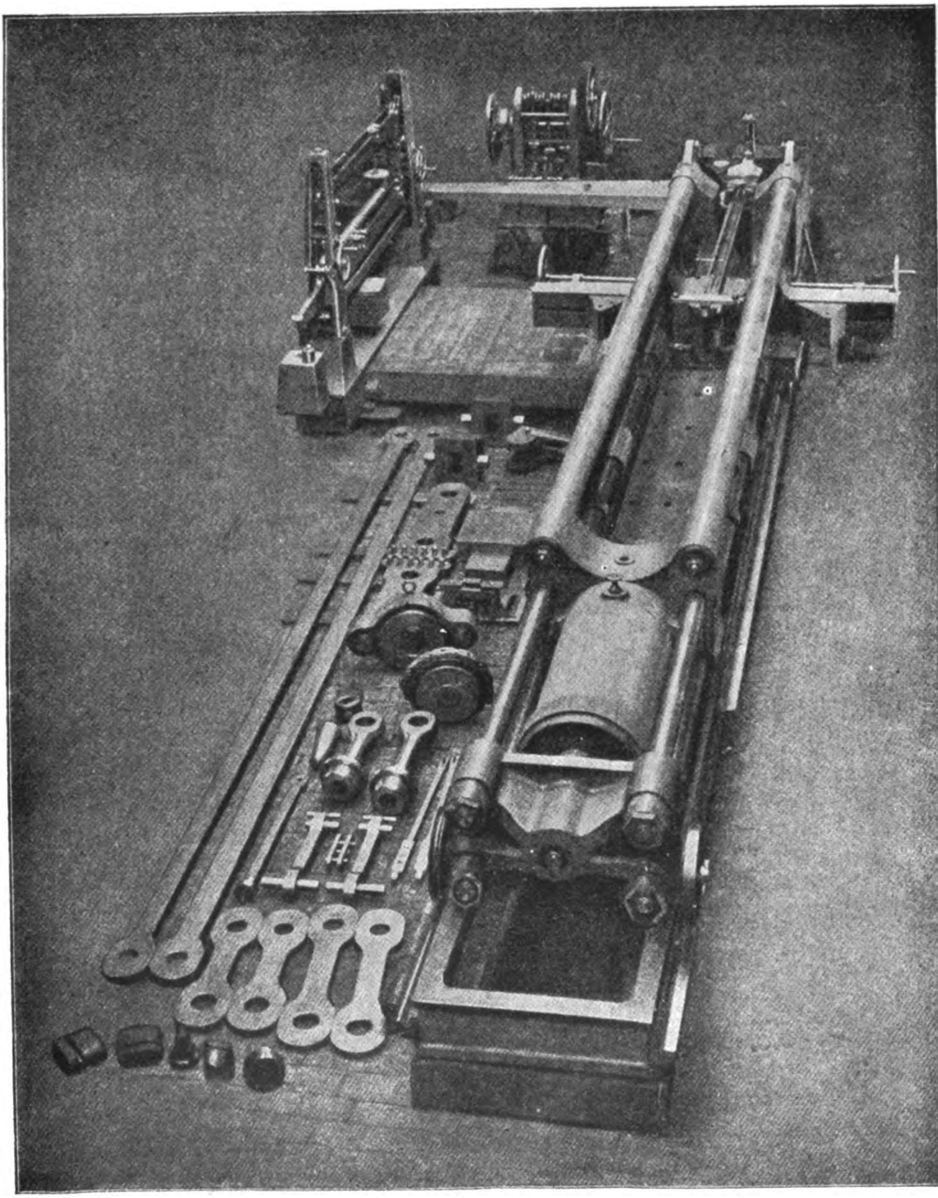


FIG. 430. (619)

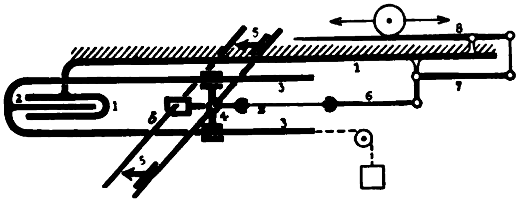


FIG.. 429. (619)

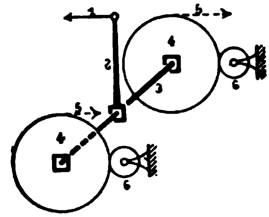


FIG. 431. (621)

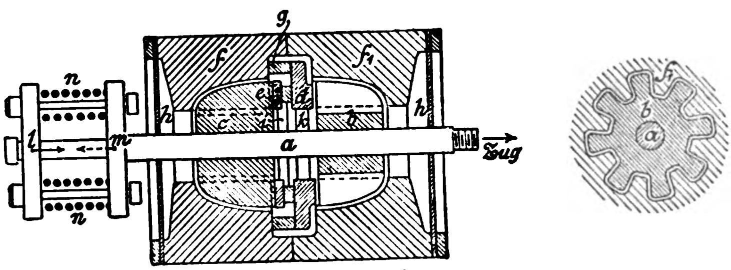


Fig. 432.

(621)

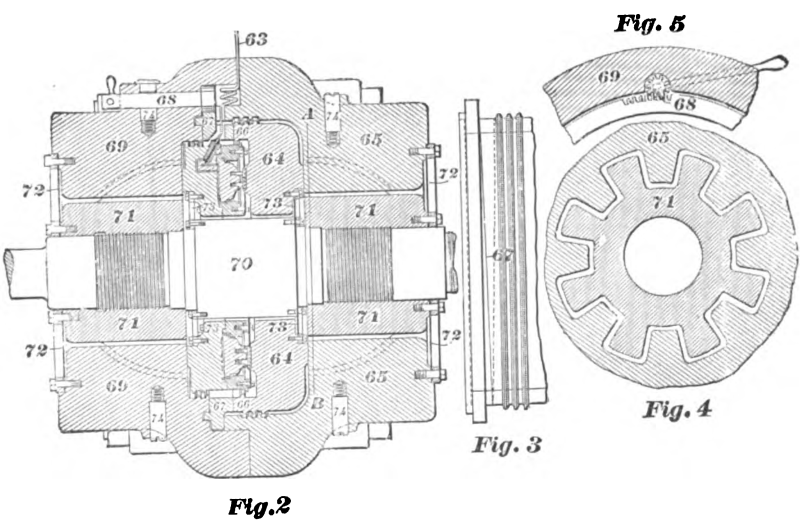


FIG. 433 (623)

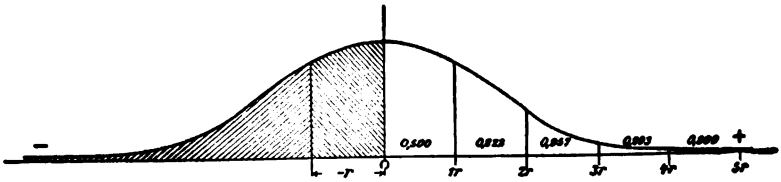


FIG. 435 (648)

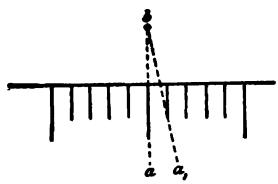


Fig. 436.
(651)

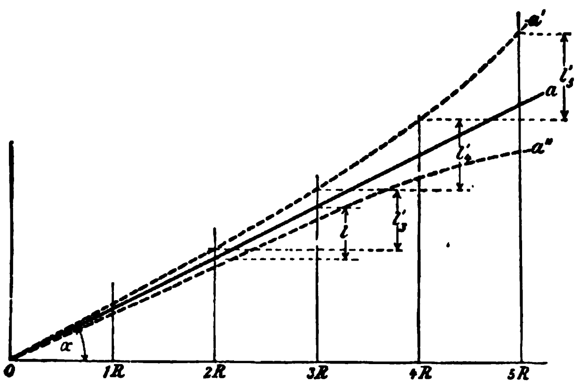


FIG. 437. (655)

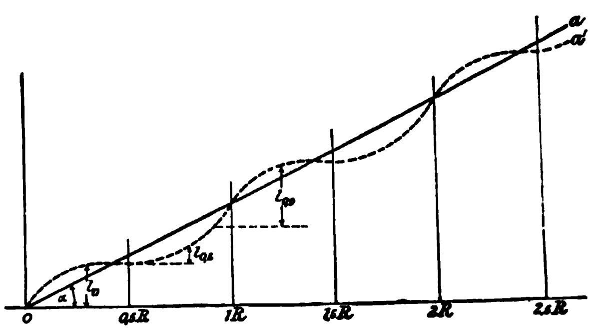


FIG. 438. (656)

Calibration of a 50,000 lbs. Olsen Machine.

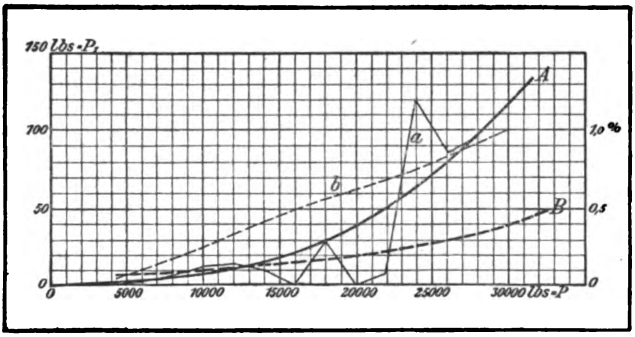


FIG. 434 (642)

Line *a* : Error of scale in lbs. observed.
" *A*: " " " " " averages.
" *B*: " " " " " in % of *P*.
" *b*: Sensitiveness (weight added to produce ⅛" motion of beam).
Trans. Am. Soc. Mech. Eng. 1892, p, 572.

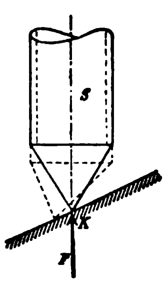
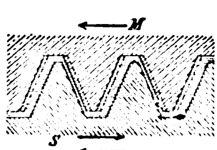


FIG. 439. (657)



FIG, 440. (658)

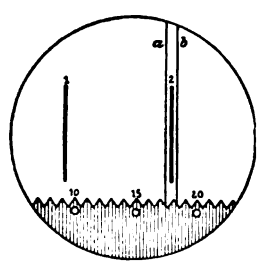


FIG. 441. (661)

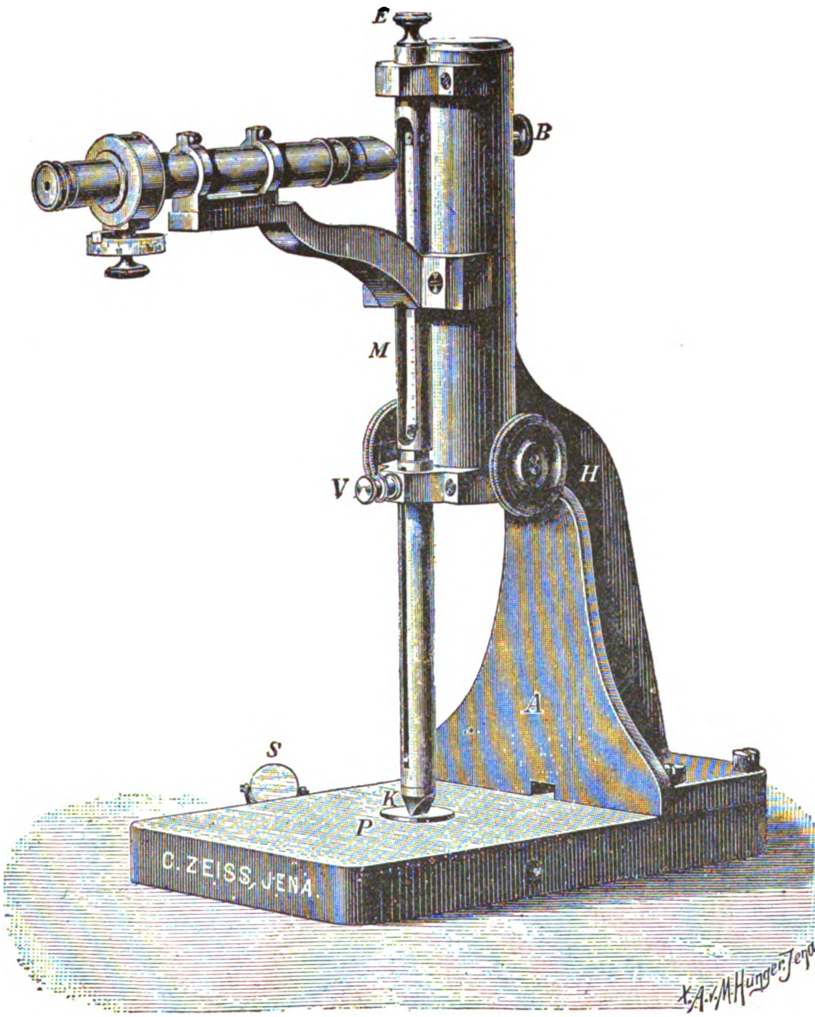


Fig. 442.

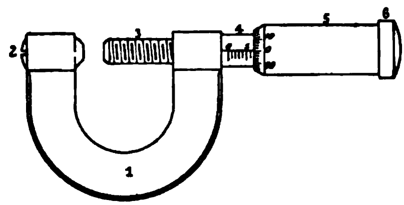


Fig. 443. (666)

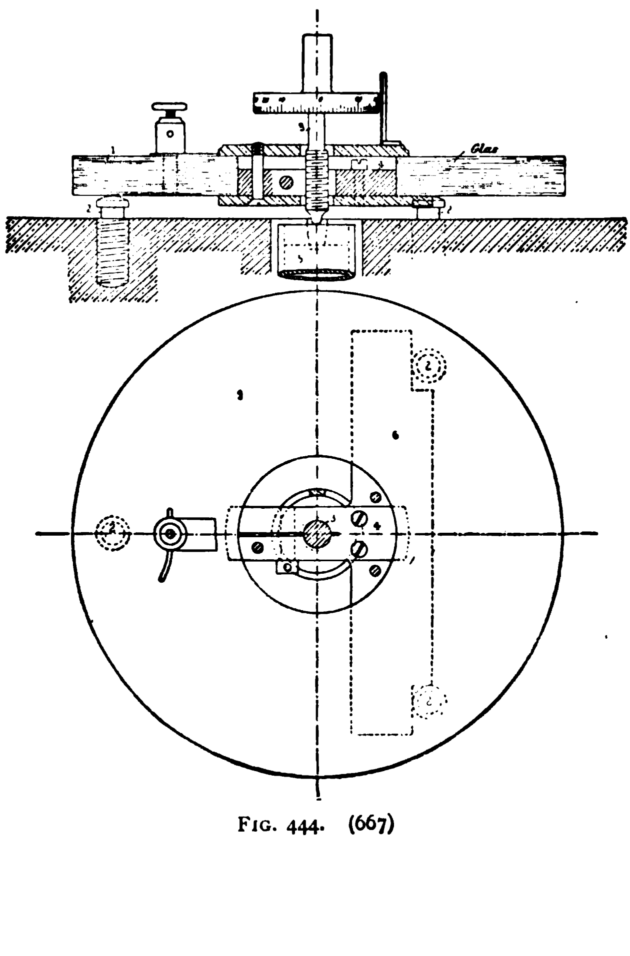


Fig. 444. (667)

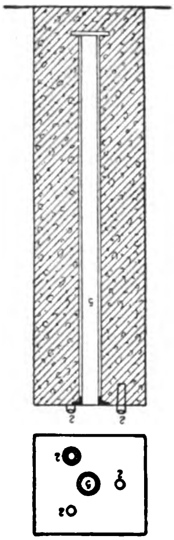


FIG. 445. (668)

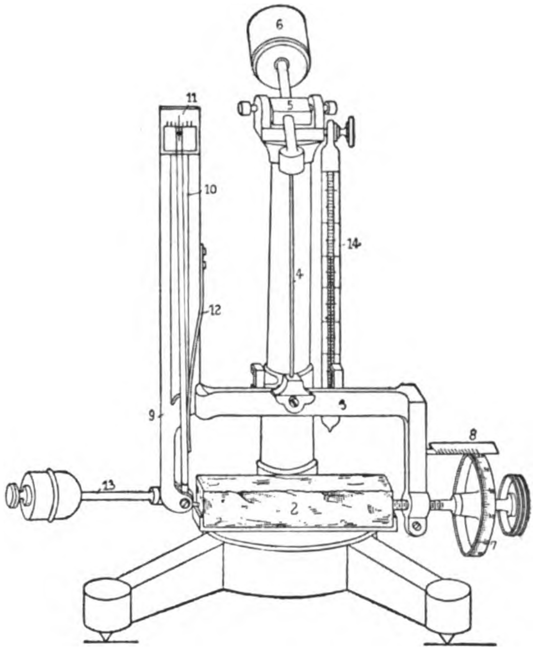


FIG. 446. (668)

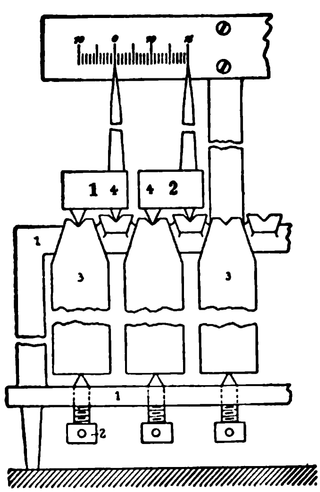


FIG. 447. (668)

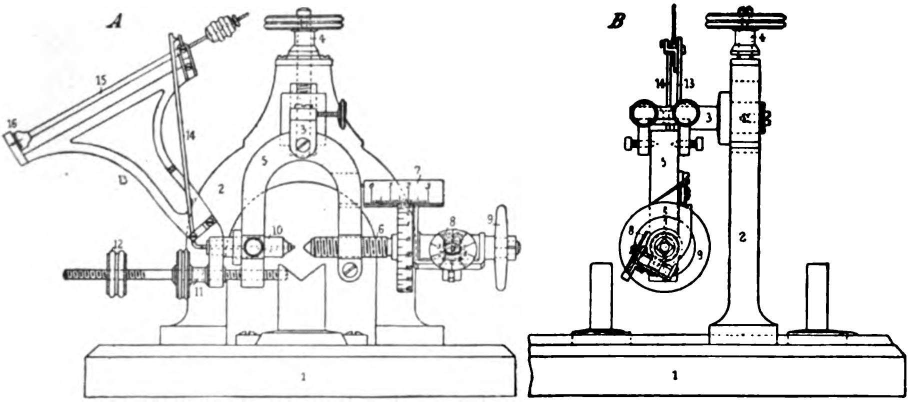


FIG. 448. (668)

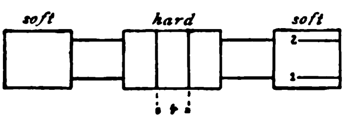


FIG. 449a. (669)

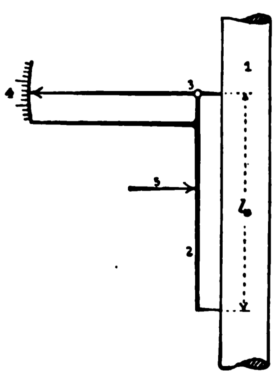


FIG. 450. (674)

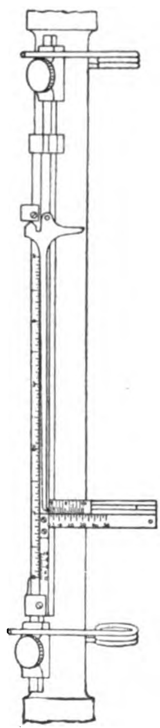


FIG. 449b. (673)

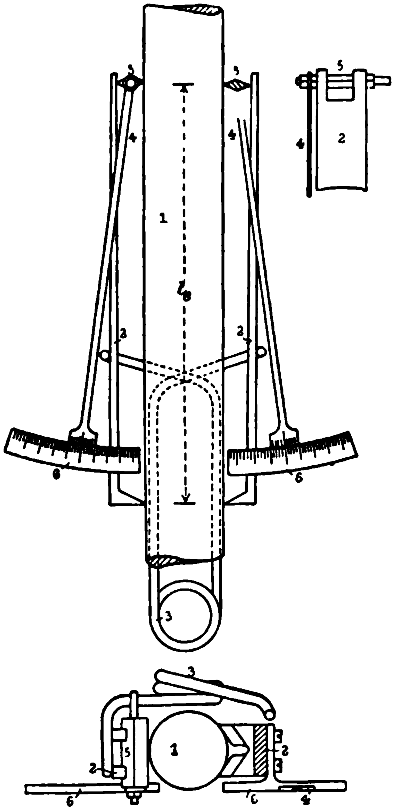


FIG. 451. (675)

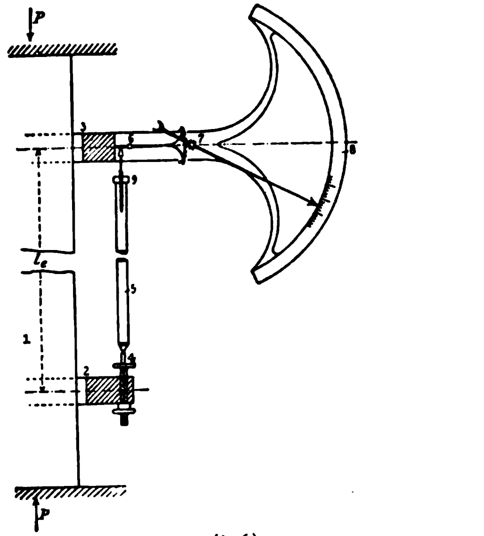


FIG. 452. (676)

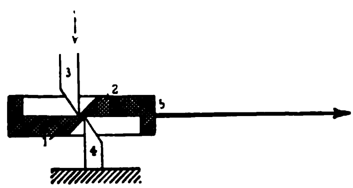


FIG. 453. (676)

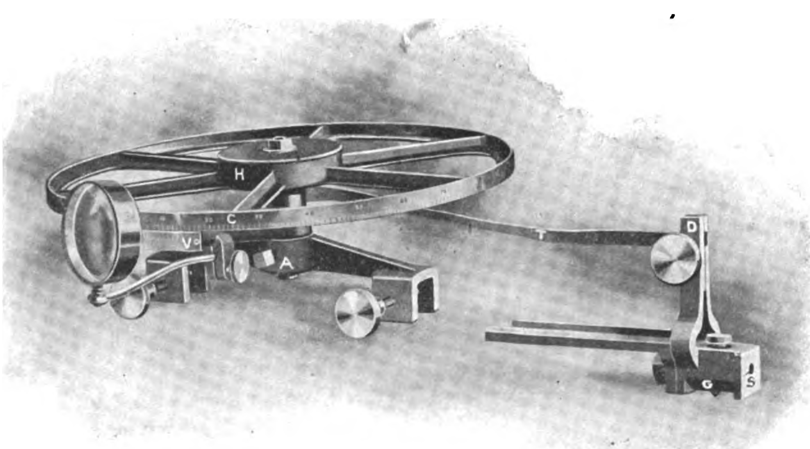


FIG. 456a.

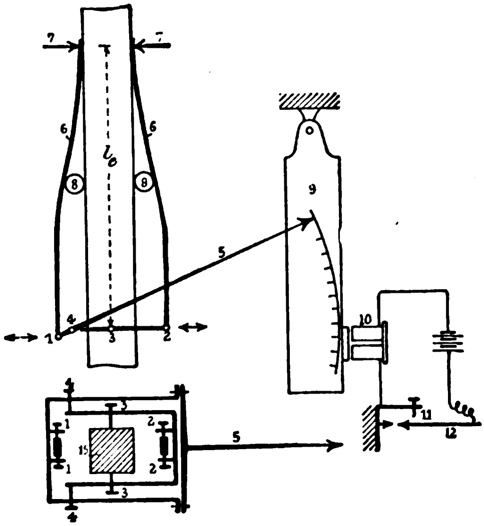


FIG. 454. (677)

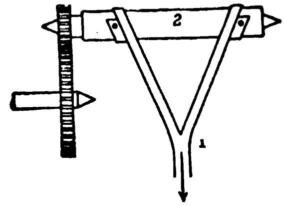


FIG. 456 (679)

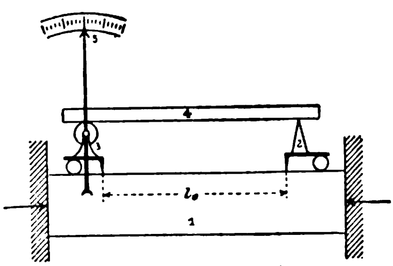


FIG. 457. (679)

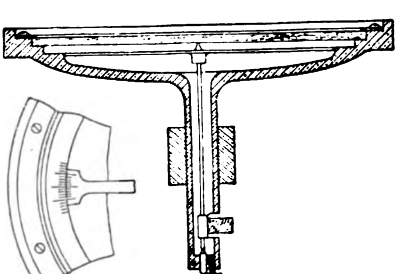


FIG. 458. (680)

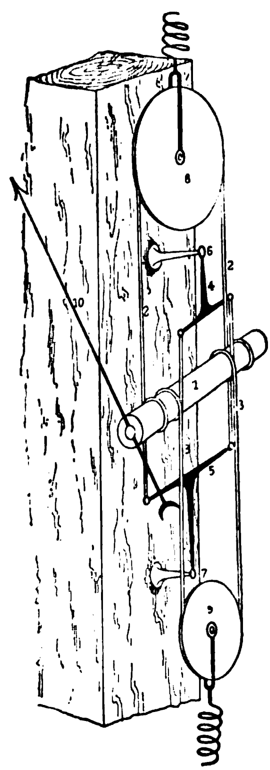


FIG. 460. (682)

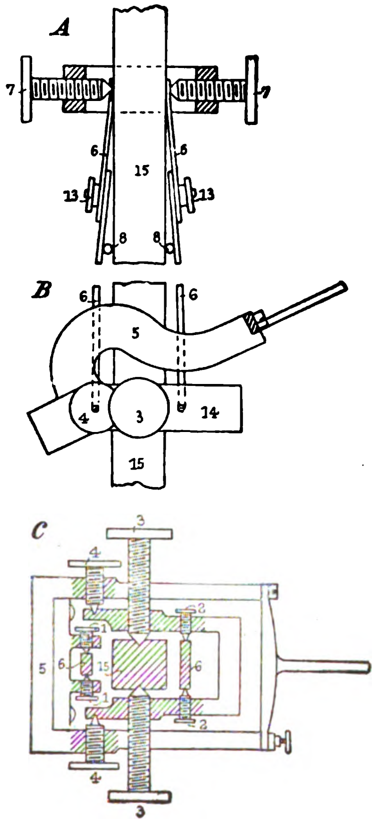


FIG. 455. (677)

FIG. 461. (682)

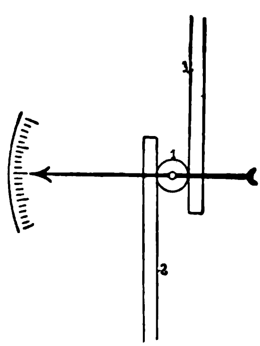


FIG. 459. (681), (683)

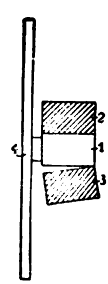


FIG. 462. (682), (683)

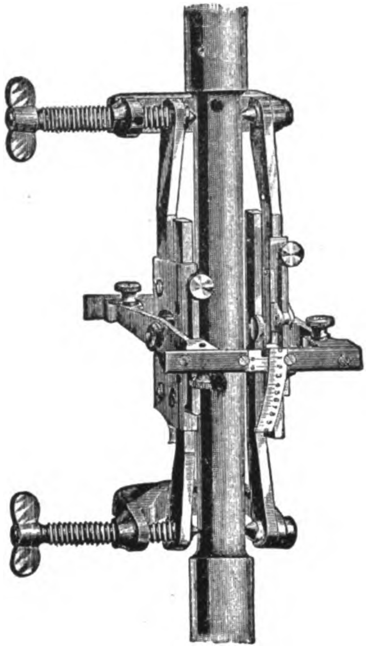


FIG. 463. (684)

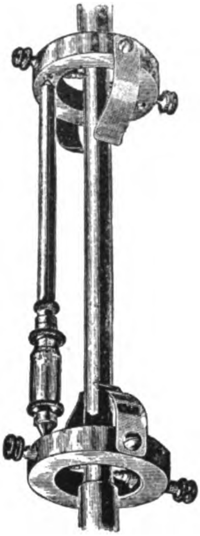


FIG. 465. (686)

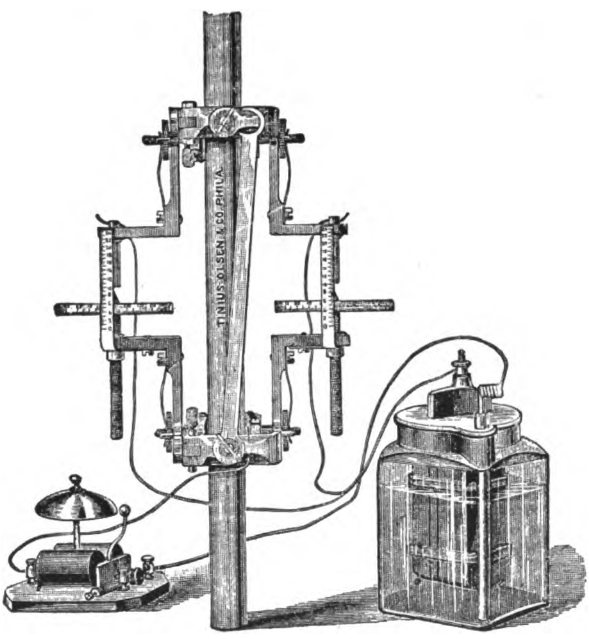


FIG. 466. (687)

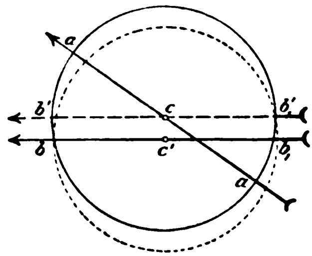


FIG. 464. (684)

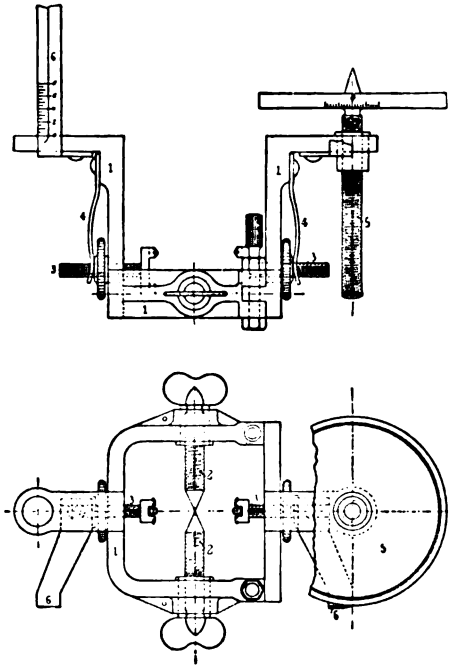


FIG. 467. (687)

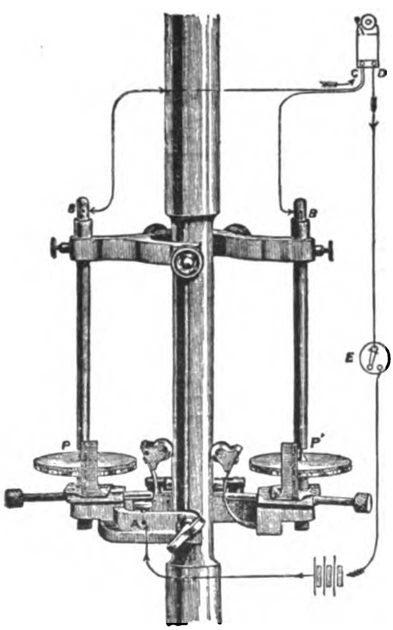


FIG. 468. (687)

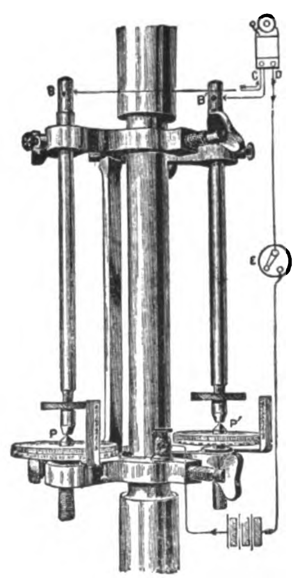


FIG. 469. (687)

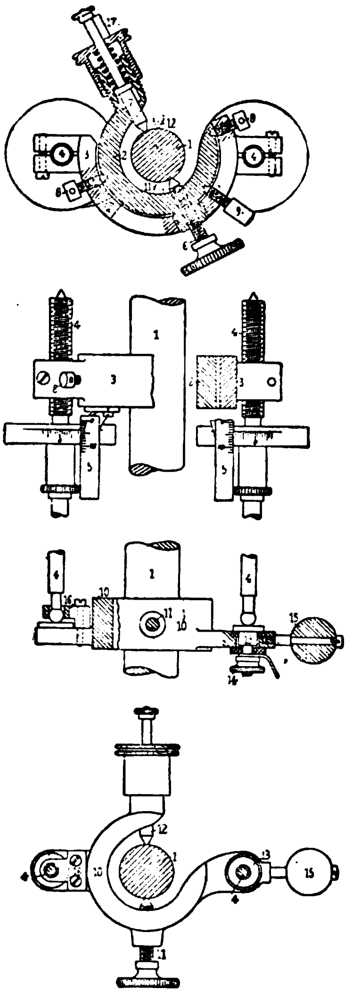


FIG. 470. (688)

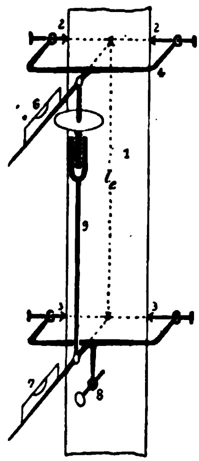


FIG. 471. (689)

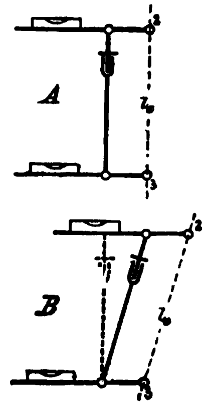


FIG. 472. (689)

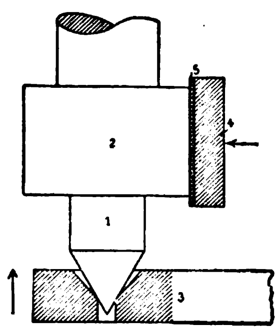


FIG. 473. (691)

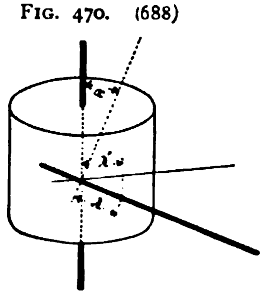


FIG. 474. (691)

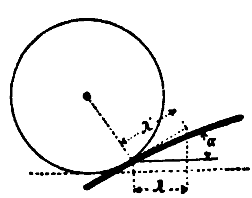


FIG. 475. (691)

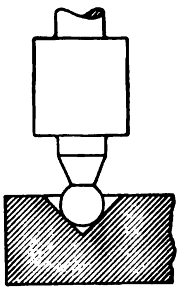


FIG. 476.
(691)

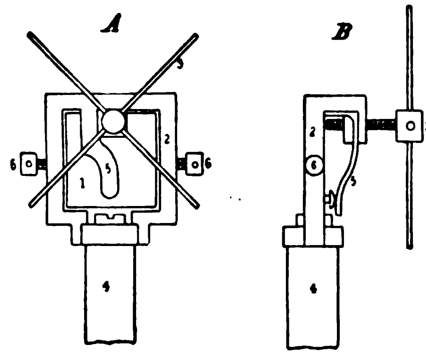


FIG. 478.
(691)

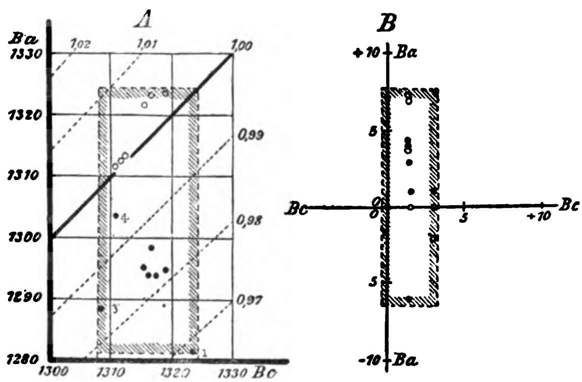


Fig. 477.
(691)

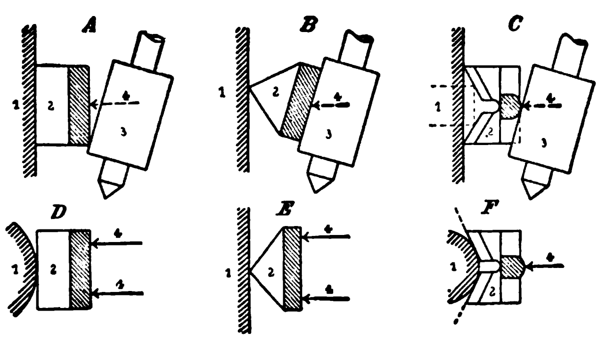


FIG. 479
(691)

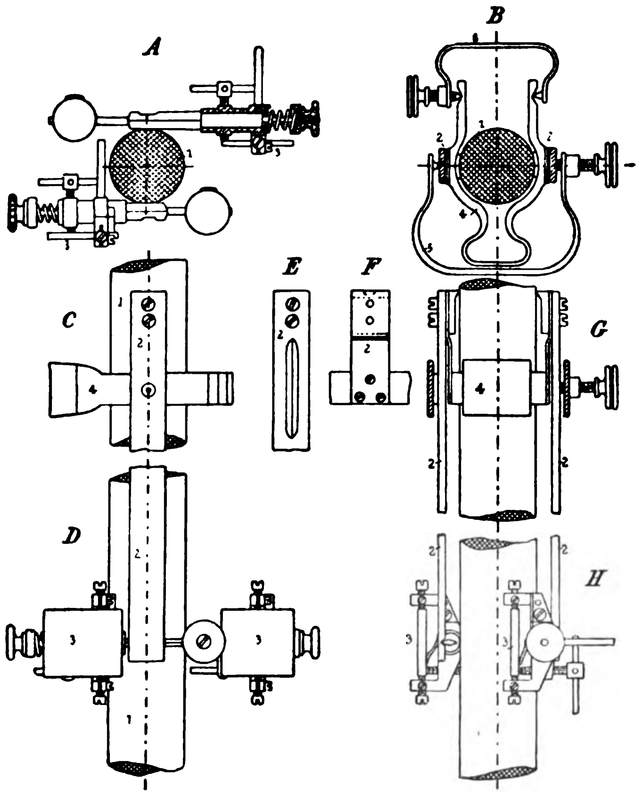


FIG. 480.
(691)

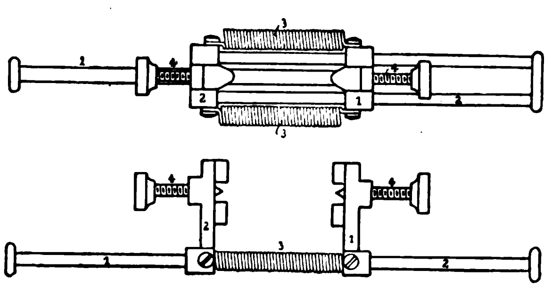


FIG. 481a.
(694)

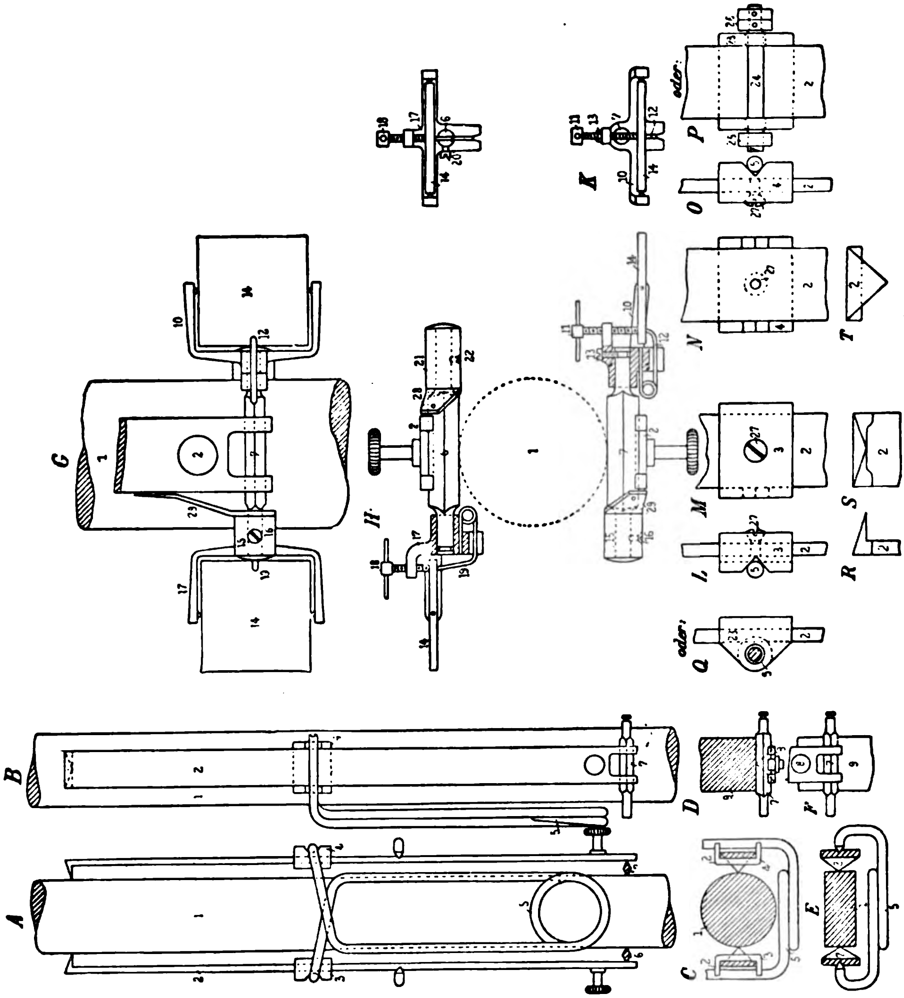


FIG. 481. (693)

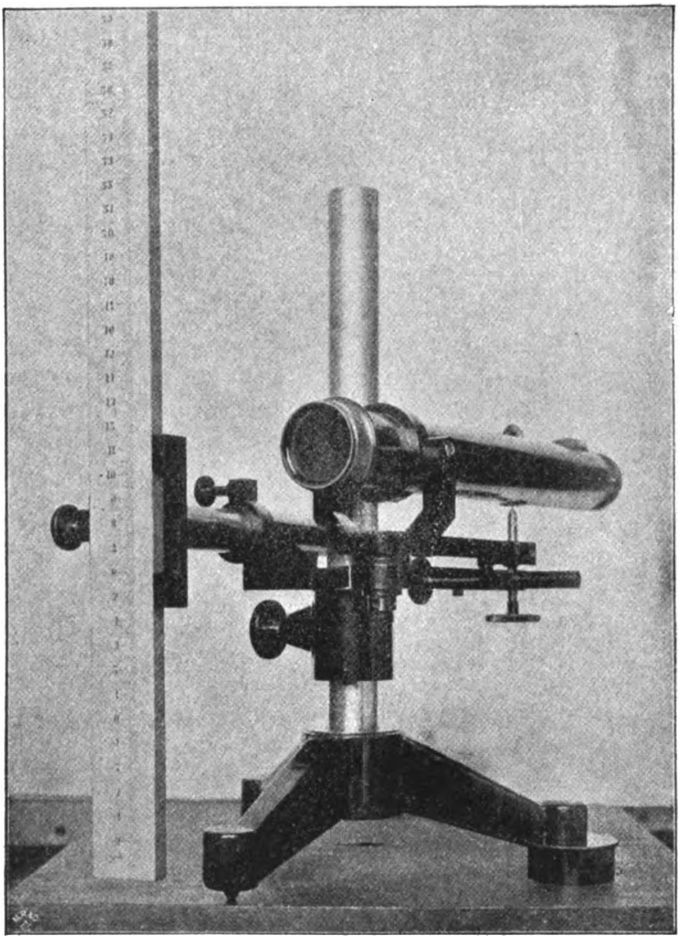


FIG. 482

(694)

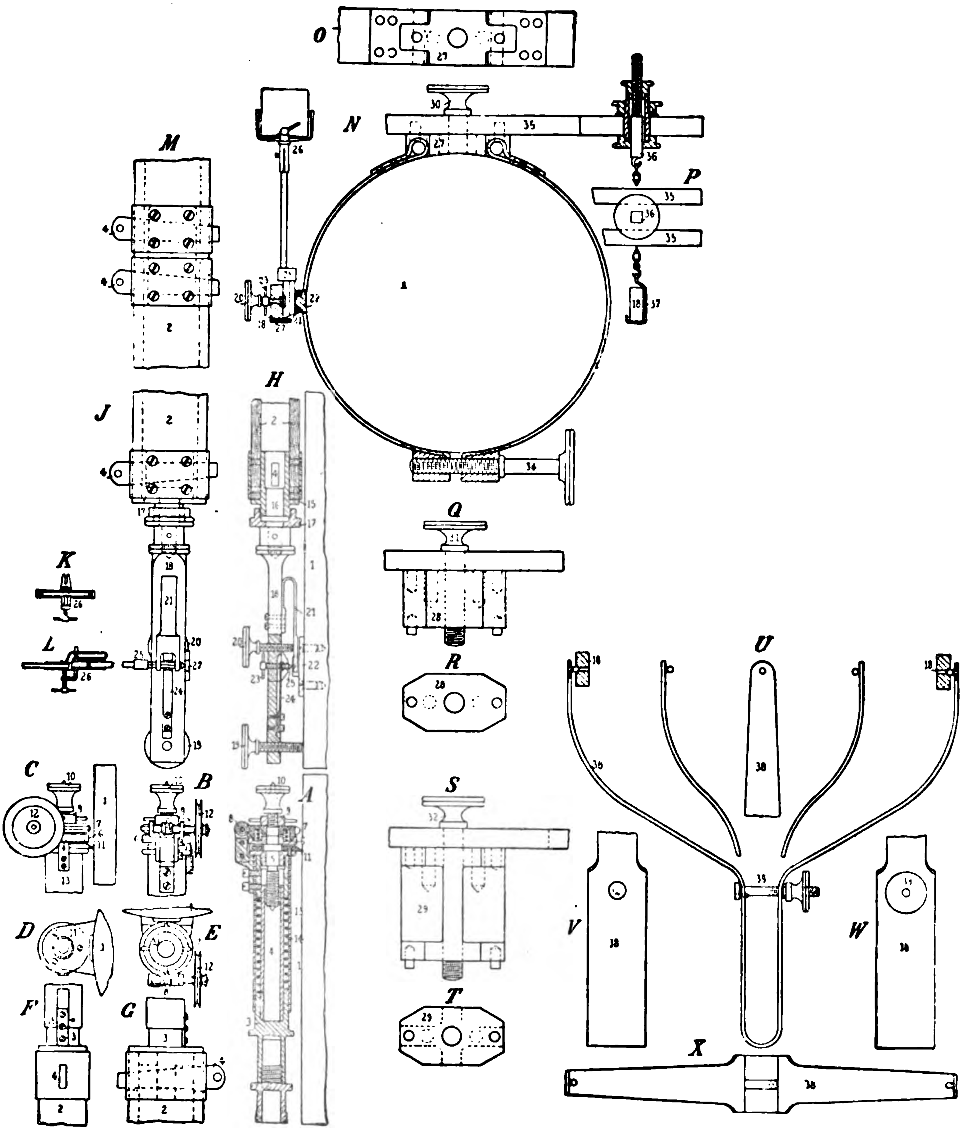


FIG. 483.

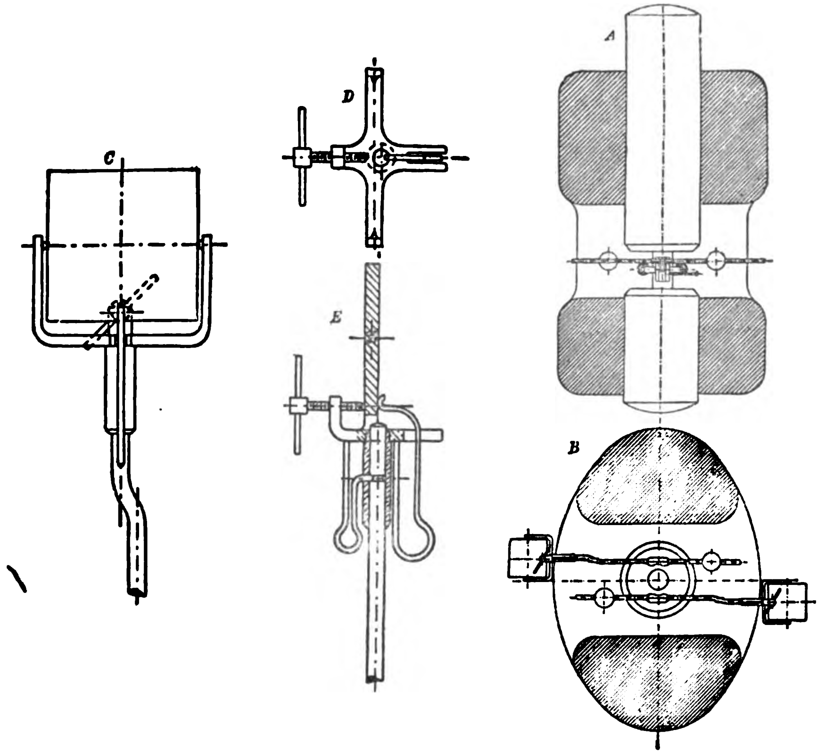


Fig. 484.
(696)

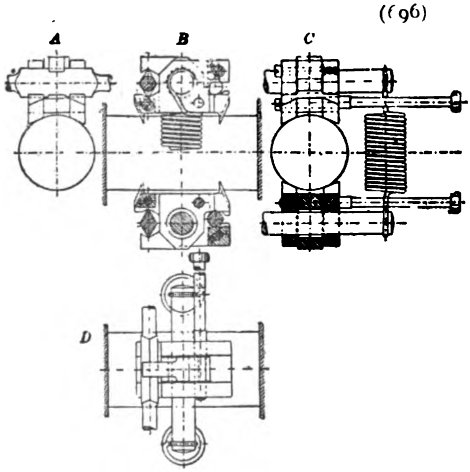


Fig. 485.
(696)

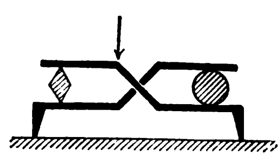


Fig. 486.
(697)

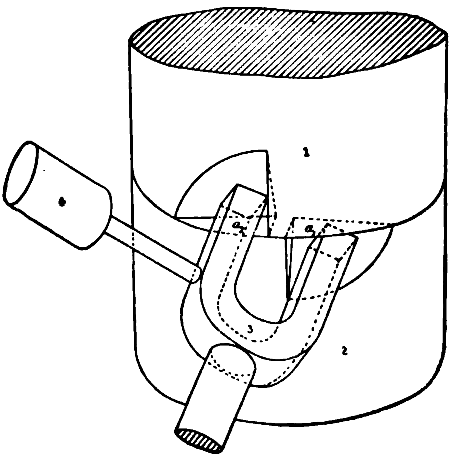


FIG. 487. (698)

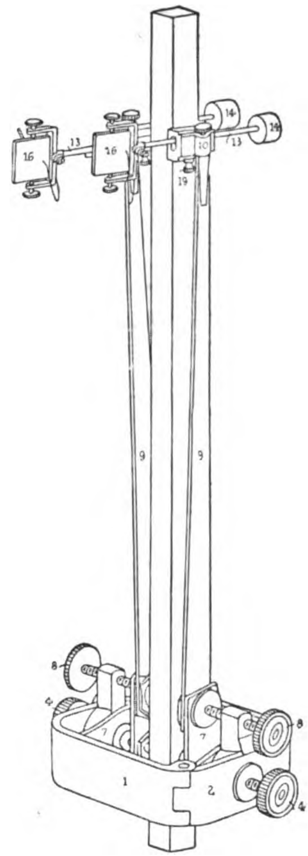


FIG. 491. (702)

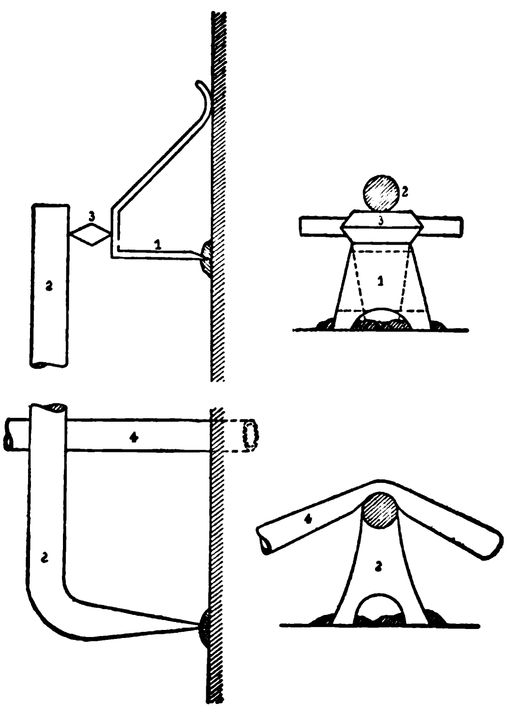


FIG. 488. (698)

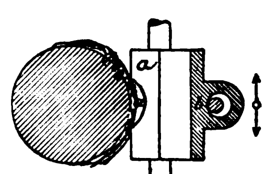


FIG. 492. (702)

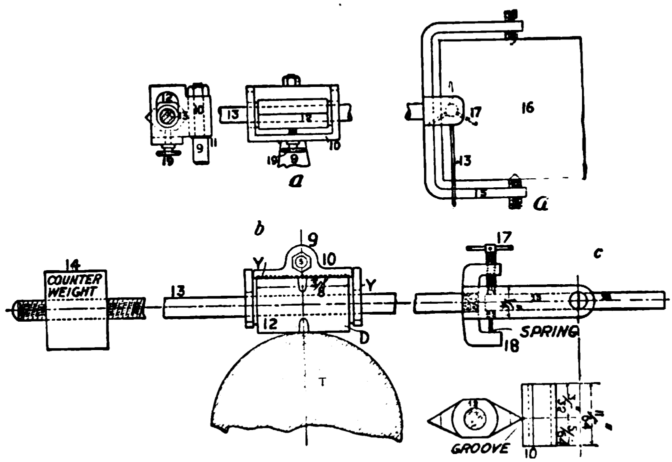


FIG. 489. (702)

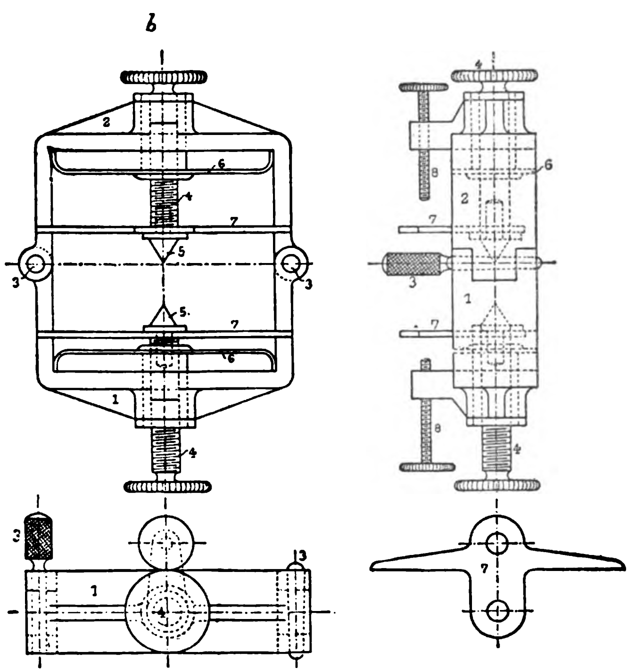


Fig. 490.

(702)

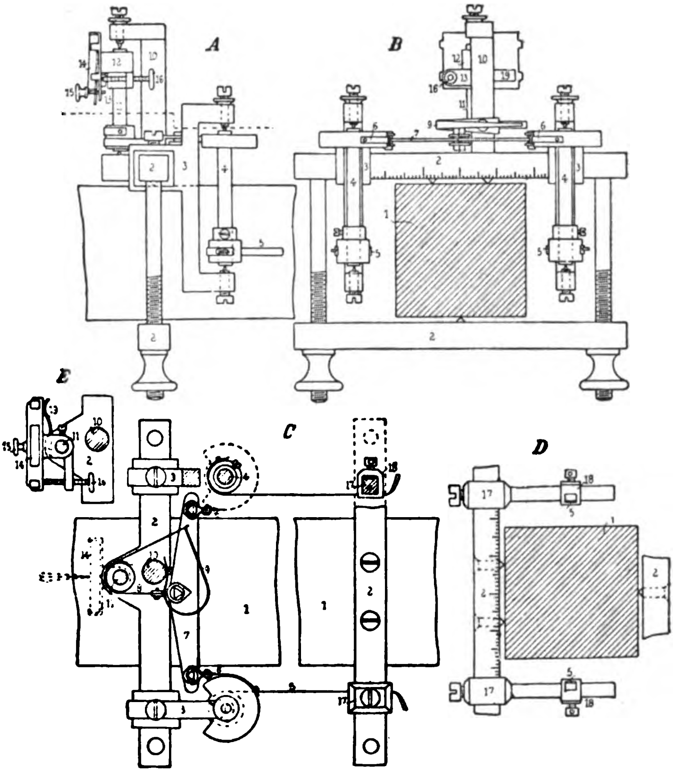


FIG. 493. (702)

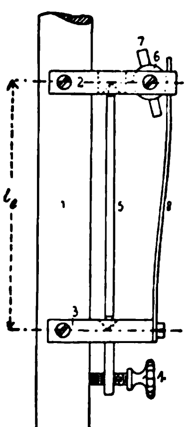


FIG. 494. (704)

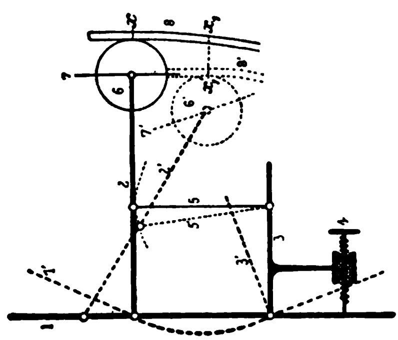


FIG. 495. (704)

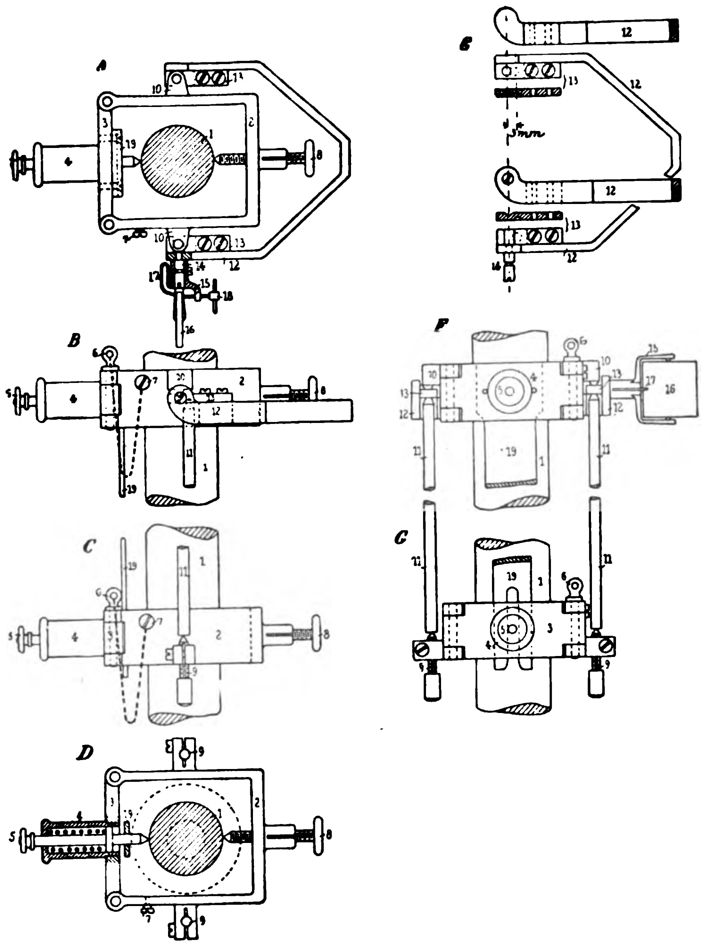


FIG. 496. (704)

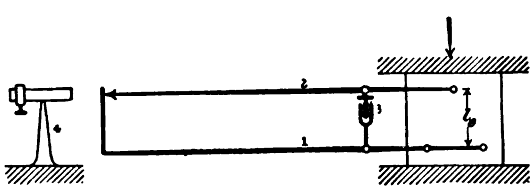


FIG. 497. (707)

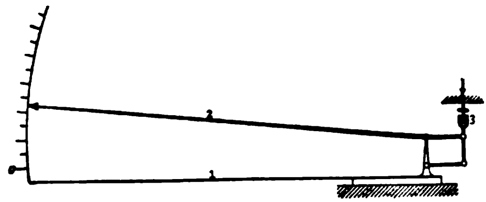


FIG. 498. 707

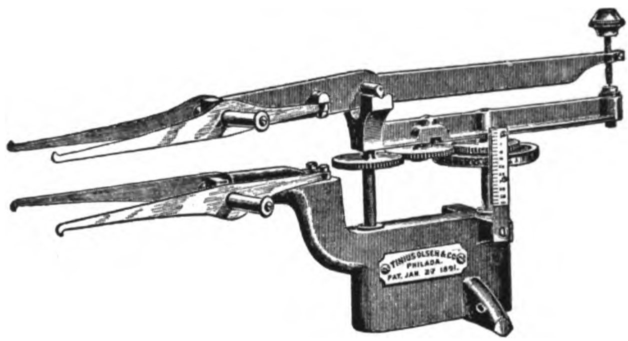


FIG. 499. (707)

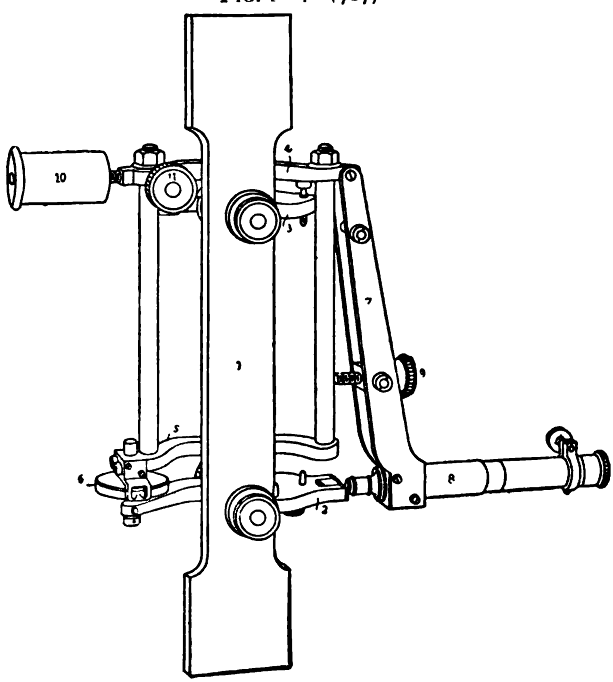


FIG. 500. (708)

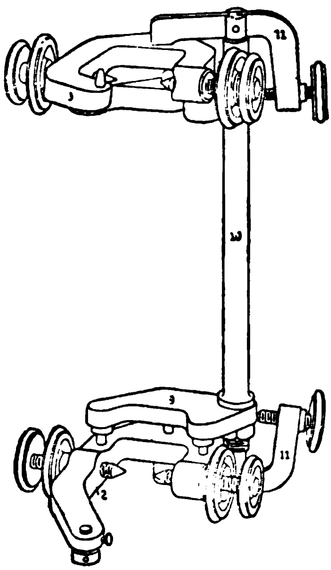


Fig. 501.

(708)

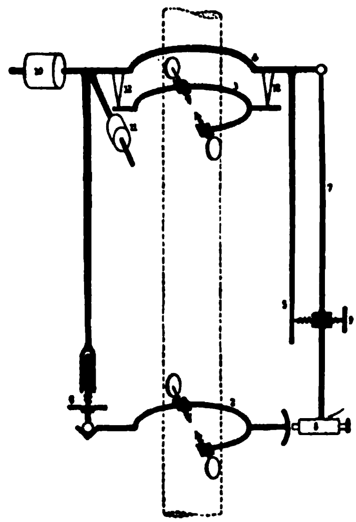


Fig. 502.

(708)

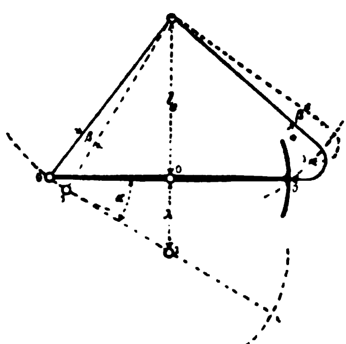


Fig. 503.

(708)

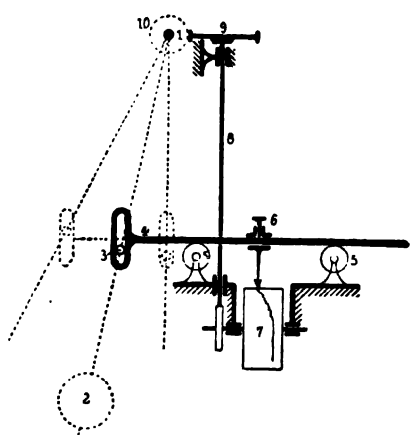


Fig. 506.

(717)

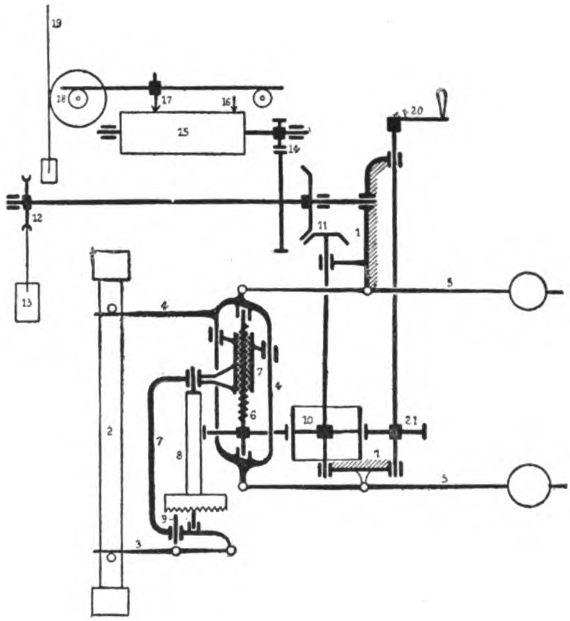


Fig. 508.
(719)

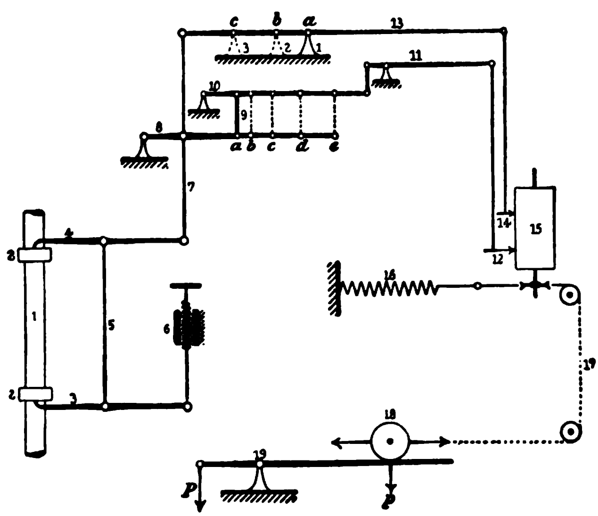


FIG. 511.
(723)

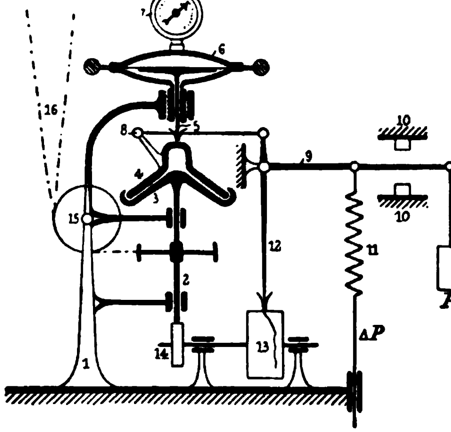


FIG. 507. (717)

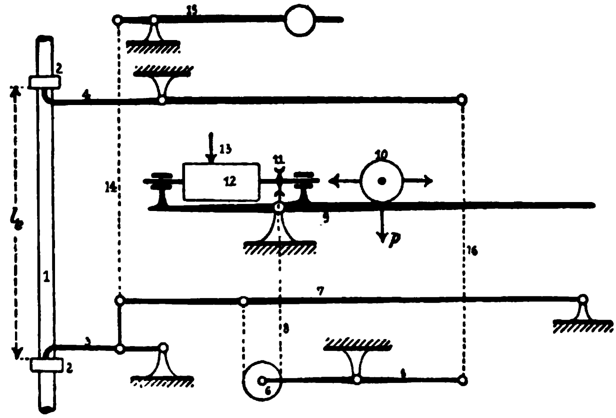


FIG. 509. (720)

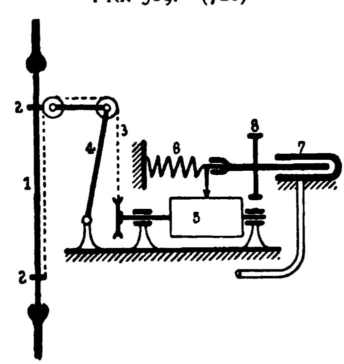


FIG. 313. (727)

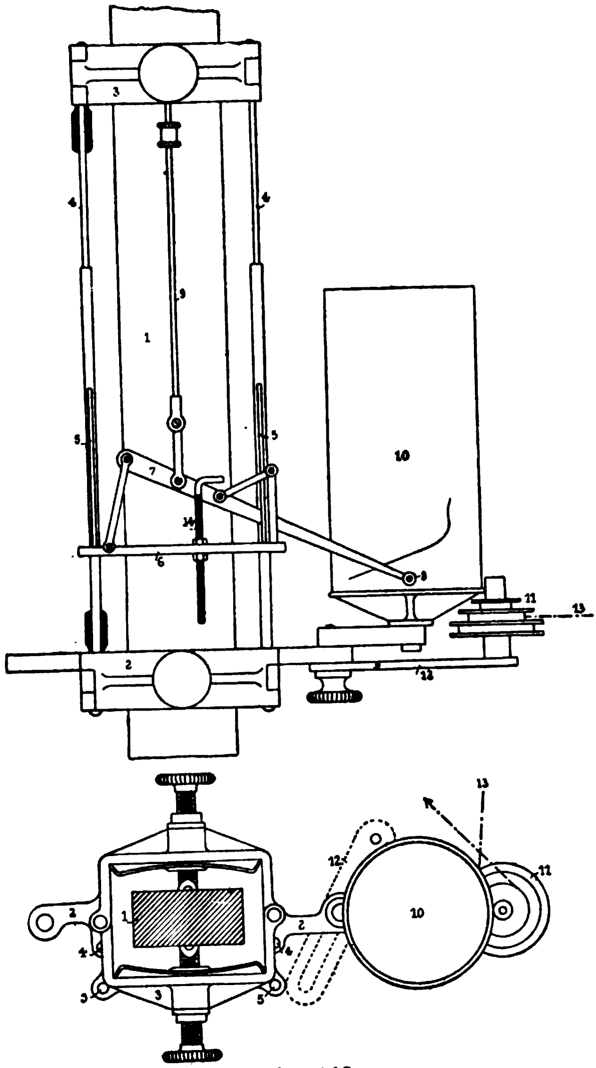


Fig. 512.
(725)

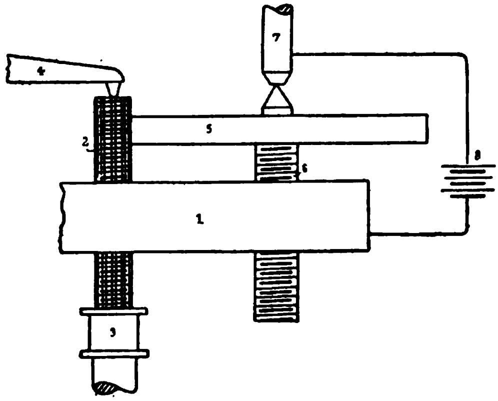


Fig. 510.
(721)

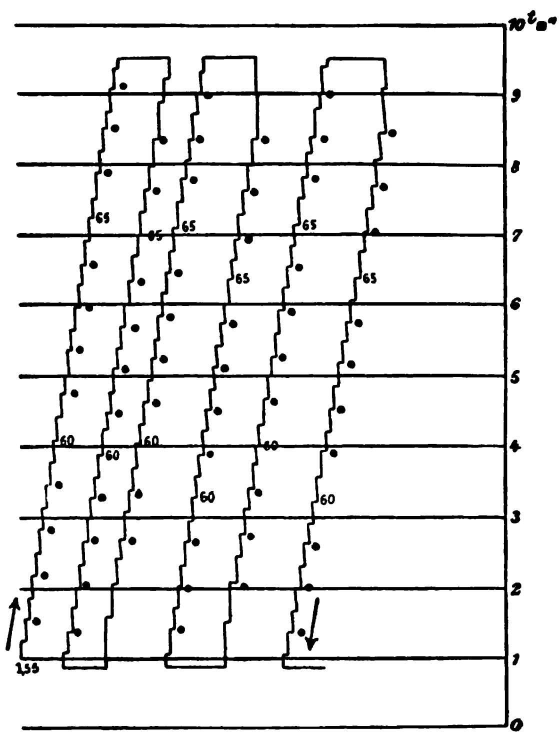


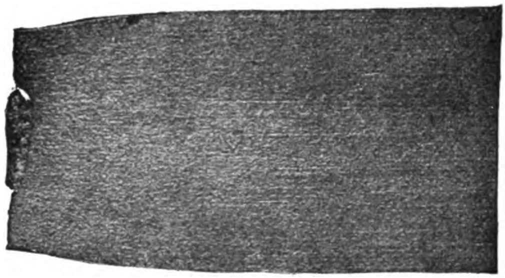
FIG. 514. (728)

EXPLANATIONS. **Plate 1.**

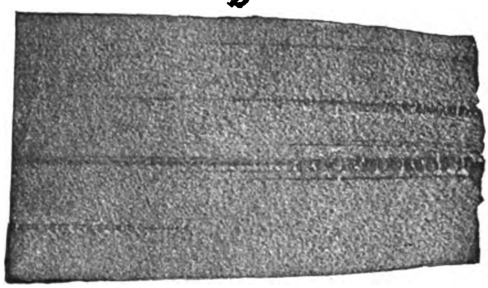
FLOW PHENOMENA AND STRESS LINES UNDER TENSILE STRESS.

1, 2. Crinkling, crinkled.
3, 11, 13. Crumpling, crumpled and 45° stress lines.
4, 8. Stress lines produced by defects.
5, 12. 45°–60° advancing stress lines regularly spaced.
6, 7, 10. Edge-streamers or lines; cross-bars or lines.
9. Grooves, grooved; folds. (See also 3 and 13.)
14–20. 45° stress lines.

1

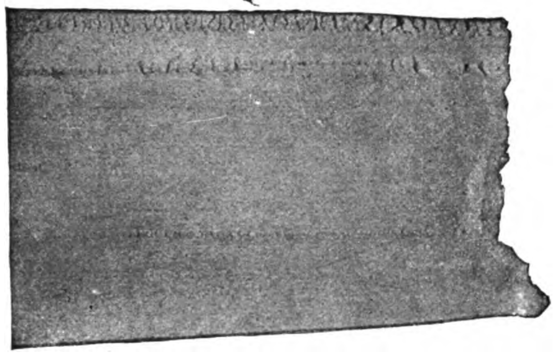


2

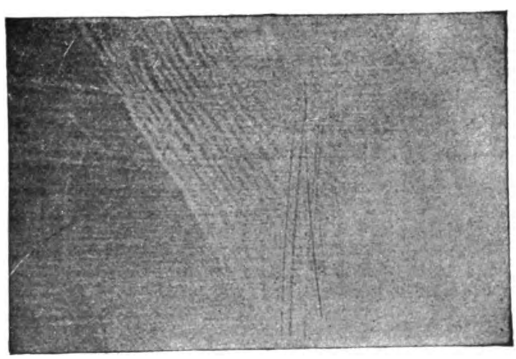


3

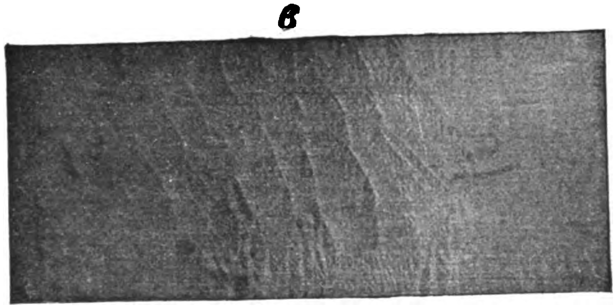
4



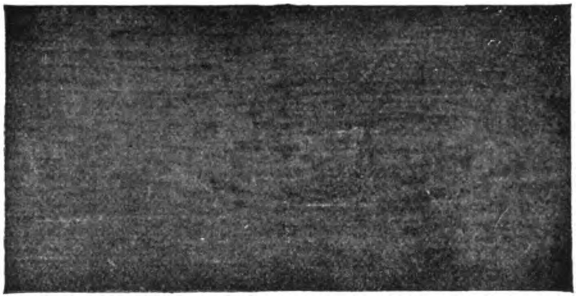
5



6

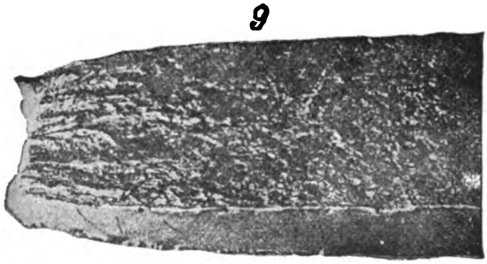


7

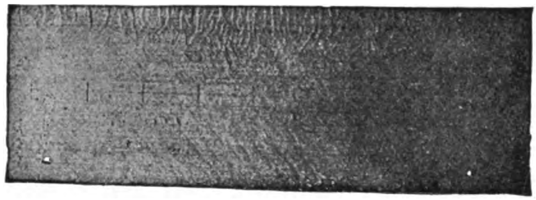


8

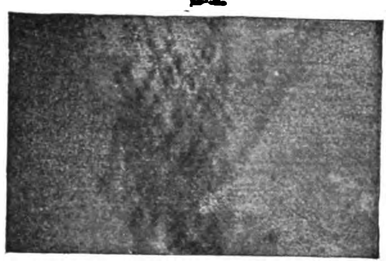
9



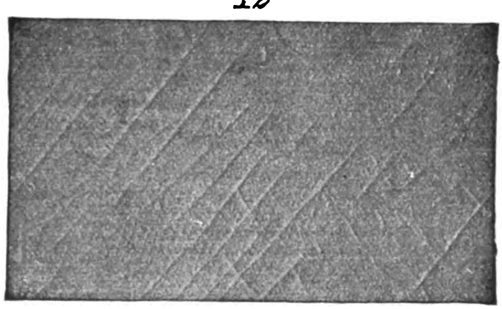
10



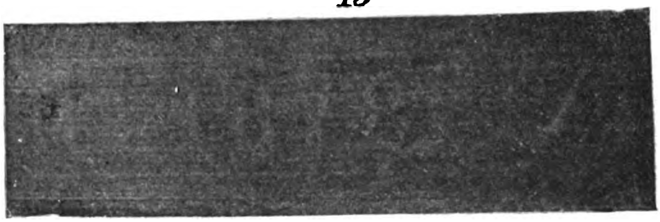
11



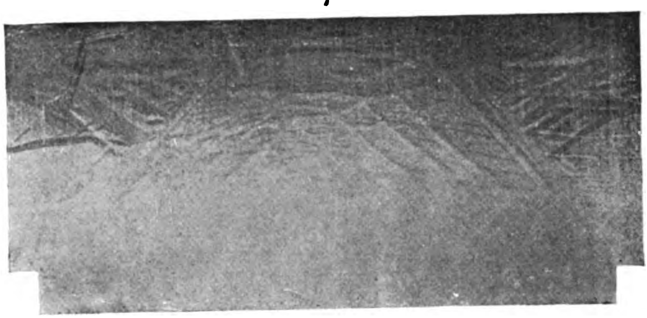
12



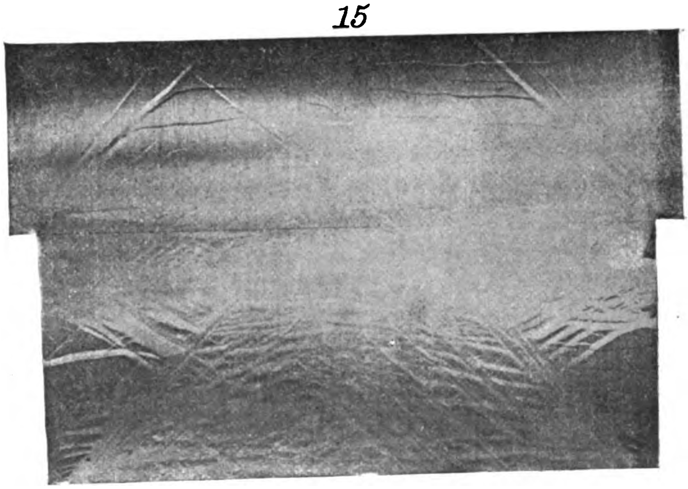
13



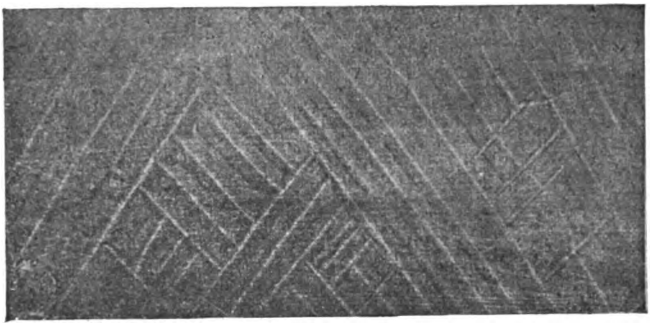
14



15

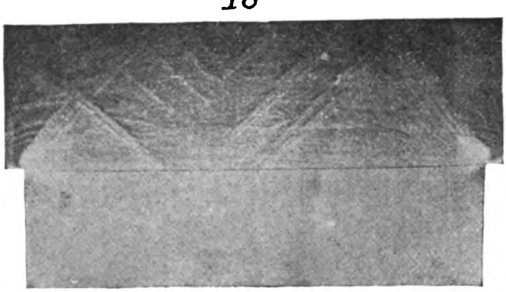


16

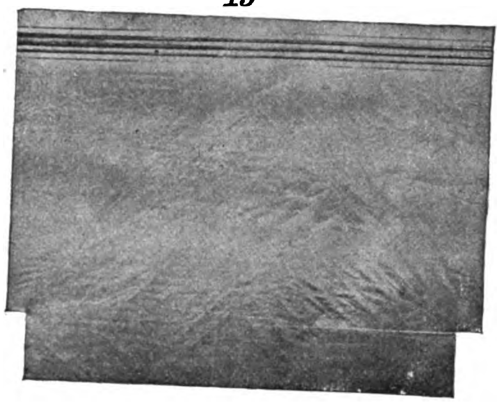


17

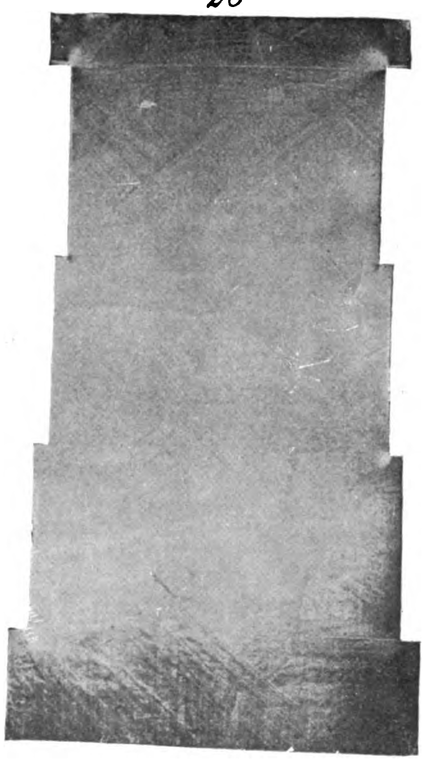
18



19



20



EXPLANATIONS. **Plate 2.**

FRACTURES, PRODUCED BY VARIOUS STRESSES (117–128. ETC.).

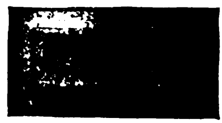
1. Pyramid, perfect.
2. Pyramid, perfect.
3. Crowned pyramid.
4. Truncated pyramid.
5. Half-crowned pyramid.
6. Crowned double pyramid.
7. Truncated pyramid.
8. Double pyramid, half-crowned.
9. Crowned truncated funnel.
10. Crowned truncated funnel.
11. Flat fracture, imperfect crown, radiated, mat core.
12. Flat fracture, radiated ring, mat core.
13. Pinnacled flat fracture, radial rays, mat core.
14. Radiation from defect.
15. Crown, radiated ring, mat core.
16. Pinnacled flat fracture, radiated ring, mat core.
17. Slightly pinnacled flat fracture, radiated ring, mat core.
18. Pinnacled flat fracture, radial rays.
19. Flat fracture, radial rays, brilliant core, fine-grained edge.
20. Coarse-grained fracture, due to defect.
21. Coarse-grained fracture, due to defect.
22. Coarse-grained fracture, due to defect.
23. Coarse-grained fracture, due to defect.
24. Half-crowned pinnacled helical fracture, double funnel.
25. Torsion fracture, cast steel (210).
26. Winding tests.
27. Normal transverse fracture (275).
28. Normal transverse fracture (275).
29. Torsion fracture, low steel (Flusseisen) (210).
30. Torsion fracture, cast iron (210).
31. Normal rail fracture (275).
32. Irregular rail fracture (275).
33. Normal rail fracture (275).
34. Noimal rail fracture (275).
35. Normal rail fracture (275).
36. Normal rail fracture (275).
37. Normal rail fracture (275).
38. Normal rail fracture (275).
39. Normal rail fracture (275).
40. Irregular rail fracture (275).
41. Stress lines in transverse rail fracture (274).
42. Stress lines, transverse rail test.
43. Fracture, transverse rail test.

1

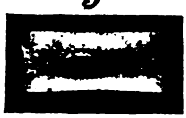
2

3

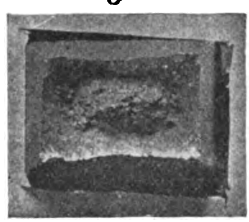
4



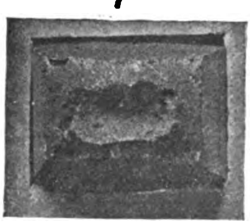
5



6



7



8

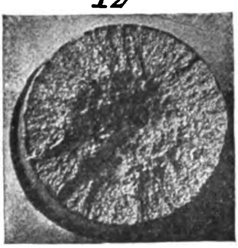
Plate 2. B.

9

10

11

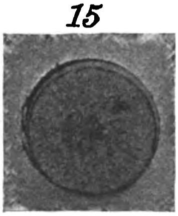
12



13

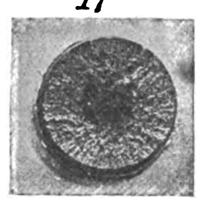
14

15

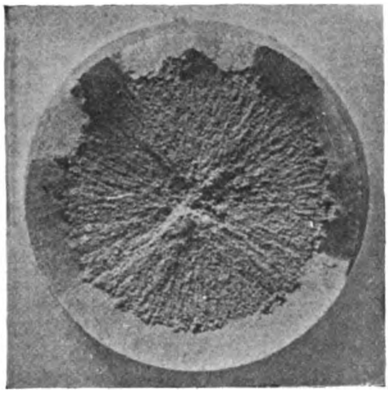


16

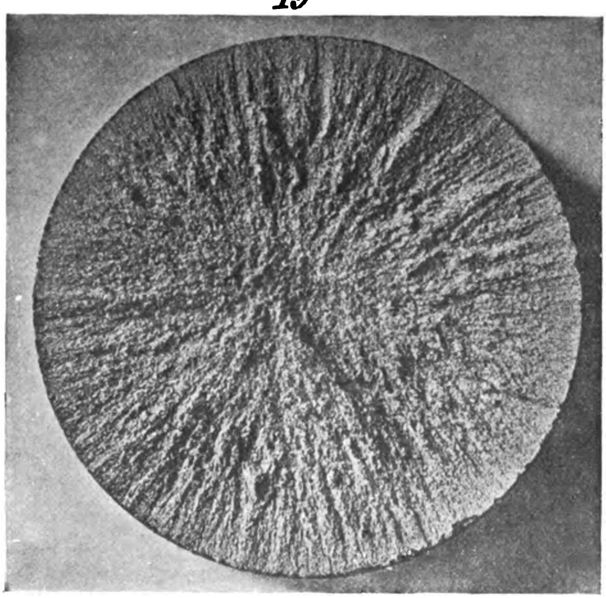
17



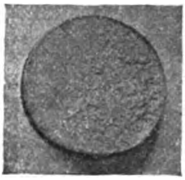
18



19

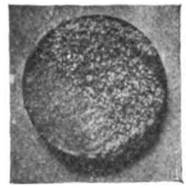


20



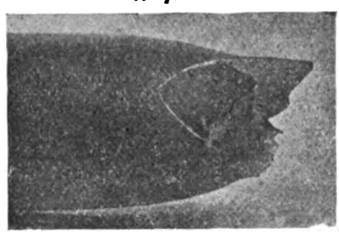
21

22

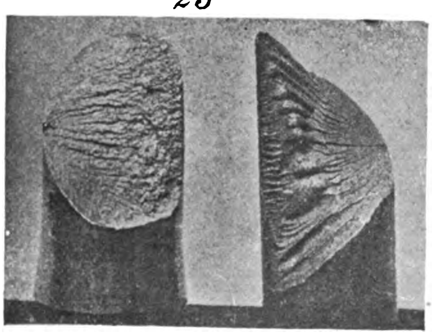


23

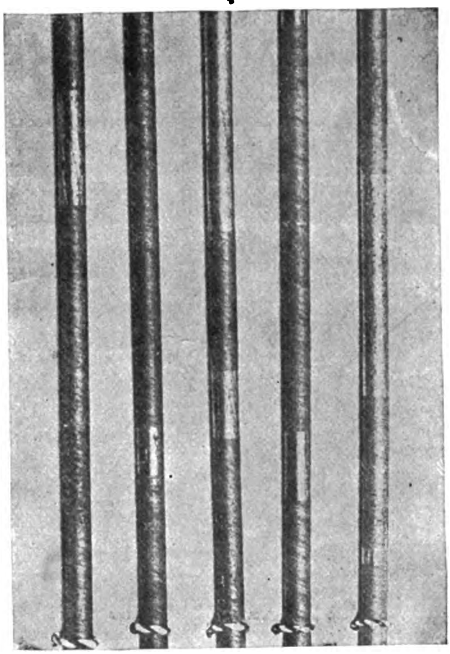
24



25

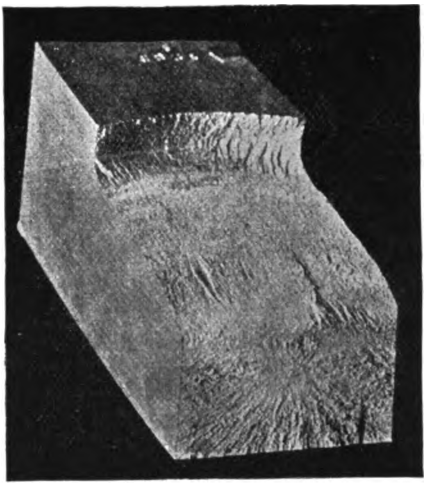


26



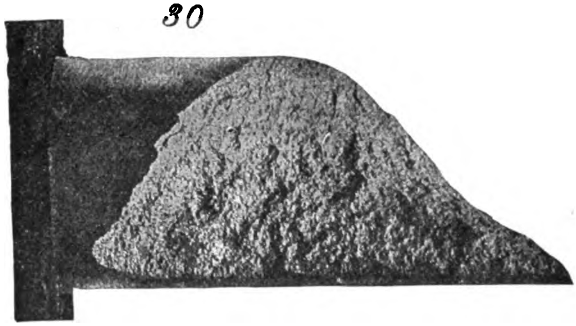
27

28



29

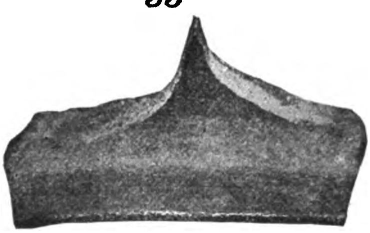
30



31

32

33

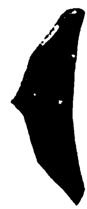


34

36 37

35

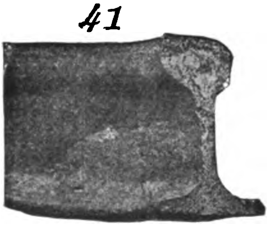
38 39



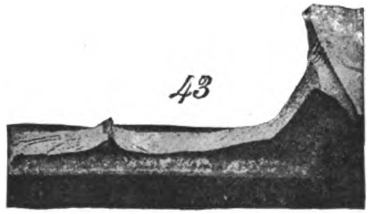
40

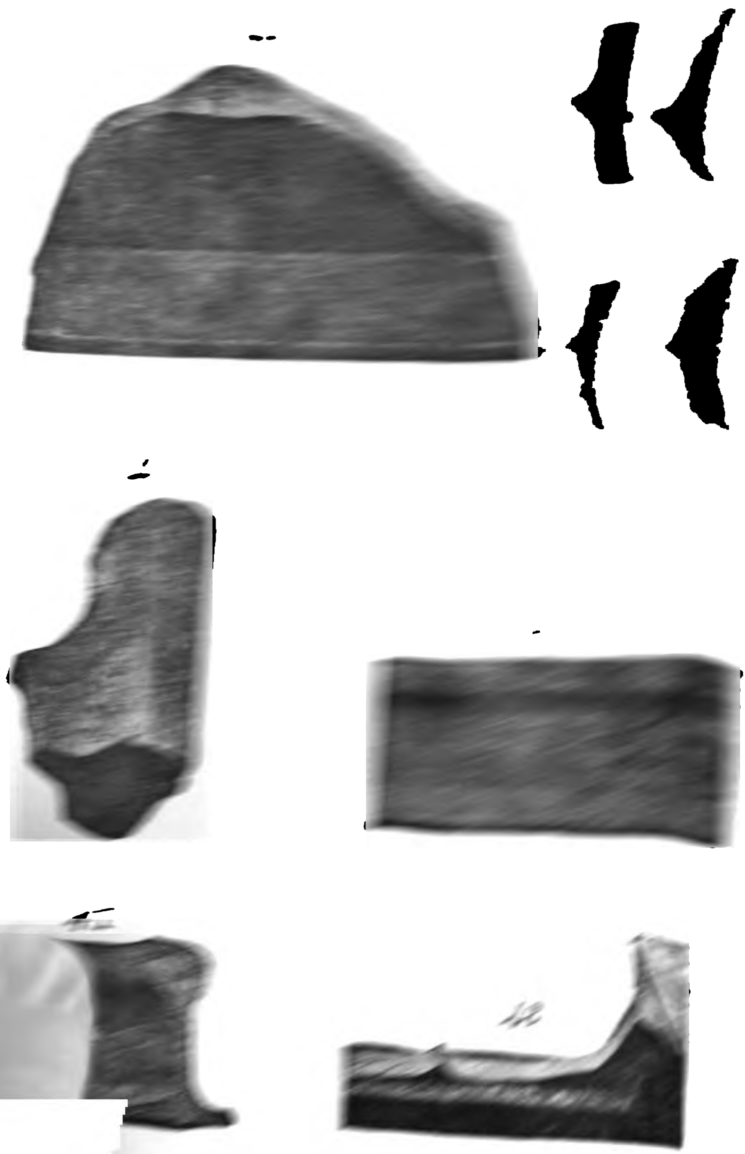
42

41



43





EXPLANATIONS. **Plate 3.**

100-TON (100,000-KG.) WERDER MACHINE.

DESIGNED BY L. WERDER, 1852, BUILT BY NUERNBERG MACHINE WORKS.

Sects. 554–573, 452, 483, 489, 495, and 497. (*L* 239.)

1-7. Arrangement for Tension-tests, for flats and rounds.

1–4. Load-indicator and driving mechanism; plan, elevation, section; Bauschinger mirror apparatus attached.
5–6. Section in front of check-scale and through main scale.
7. Elevation of telescope-stand.

8-12. Arrangement for Thrust-tests.

8. Longitudinal section.
9–11. Elevation.
12. Section at the hydraulic cylinder.
} Bauschinger instruments of precision attached.

13-18. Arrangement for Crushing-tests.

13–16. Holders.
17–18. Attached to machine.
} Bauschinger's mirror apparatus attached.

19-22. Arrangement for Shearing-tests.

19–20. For double shear.
21–22. For single shear.

23-25. Arrangement for Transverse Tests.

23. Plan.
24. Longitudinal section.
} With Bauschinger's apparatus.
25. Section at the hydraulic press.

26-30. Arrangement for Torsion-tests.

26–30. Plan, with Bauschinger's measuring-apparatus.
27. Section, through axis of test-piece.
28–29. Elevation.

31-36. Bauschinger's Measuring-apparatus.

31. Telescope mount for torsion-tests.
32–34. Mirror apparatus for tension and crushing-tests
35–36. Microscopes for thrust-tests.

EXPLANATIONS. **Plate 4.**

WERDER TESTING-MACHINES.

DESIGNED BY L. WERDER, BUILT BY NUERNBERG MACHINE WORKS.

Sects. 565, 571.

1-5. Plan and Travelling-crane for the 100-ton Machine (Plate 3).

1–2. Elevation and section through laboratory.
3–5. Details of travelling-crane.

5-15. Werder Machine of 50 tons capacity.

6. Plan.
7. Longitudinal section.
8. Elevation of driving mechanism.
9. Scale and valves.
10–12. Arrangement for crushing-test.
13–15. Arrangement for tension-test.

16-21. New Arrangement for Torsion-tests for the 100-ton Machine.

16–17. Plans.
18. Elevation, driving mechanism.
19–20. Sections through axis of test-piece and between lever and hydraulic cylinder.
21. Side elevation, lever, and hydraulic press.

EXPLANATIONS. **Plate 5.**

50-TON (50,000-KG.) MARTENS MACHINE.

DESIGNED BY A. MARTENS, 1884, BUILT BY NUERNBERG MACHINE WORKS.

Sects. 524, 530, 546, 566–573, 530, and 563. Pl. 5, 11, 13. (*L 113*, *115*, and *162*.)

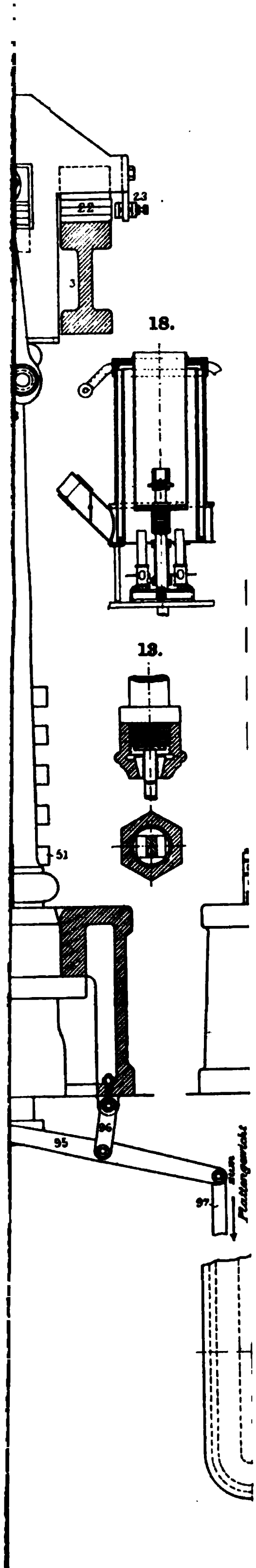
1. Section through axis of machine.
2. Transverse section.
3. Elevation.
4. Check-weights. } With depositing mechanism.
5. Poise-weights. }
6. Top view, bearing of lever.
7. Plan and horizontal section.

8, 9. Intensifier and circuit-breaker

10. Main knife-edge.
11. Supports of balance-weights.

12–17. Holders.

18. Heating-furnace for hot tests.


22
23
3
18.
13.
51
95
96
97
zum Plattengewicht

EXPLANATIONS. **Plate 6.**

50-TON (50,000-KG.) TESTING-MACHINE.

MOHR & FEDERHAFF, MANNHEIM, GERMANY.

Sects. 72, 376, 479, 492, 493, 574–582. **Pl. 6 and 7.** (*L 12*, 1884, p. 141; *27*, 1884, p. 545.)

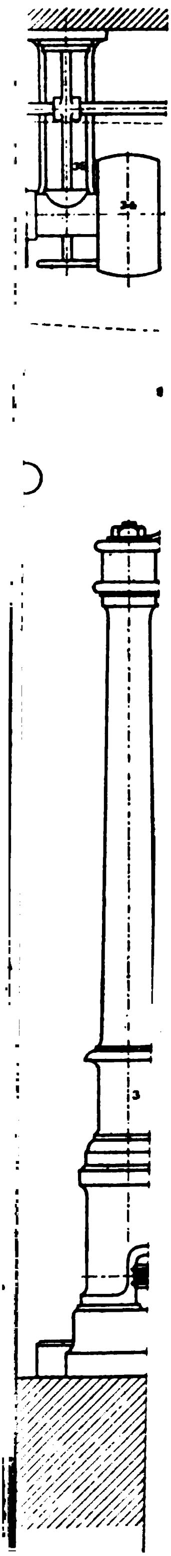
1, 2. Elevations (hand-power shown by dotted lines in Fig. 2).

3, 4. Mechanical Drive.

5-8. Apparatus for Crushing-tests.

11-20. Holders.

11, 16, 17. Rope.
12–15, 18–20. Rounds and flats.



EXPLANATIONS. Plate 7.

MOHR & FEDERHAFF TESTING-MACHINES.

MANNHEIM, GERMANY.

Sects. 72, 376, 479 492, 493, 517, 574–582. (*L 12*, 1884, p. 141; *27*, 1882, p. 545.)

Notation : *L* = capacity ; *S* = size, length, breadth, height ; *T. P.* dimensions of test-piece.

Tension, Crushing, and Transverse Test Machines ; hydraulic power ; built :

Fig.	5	5	5
L =	90*t*	75*t*	60*t*
S =	10 ft. 10 × 16 ft. 9 × 13 ft. 8	10 ft. 10 × 15 ft. 5 × 10 ft.	10 ft. 10 × 15 ft. × 10 ft.
Fig.	5	5	5
L =	50*t*	50*t*	30*t*
S =	10 ft. 10 × 10 ft. 1 × 12 ft. 1	10 ft. 10 × 9 ft. 10 × 9 ft. 3	10 ft. 10 × 9 ft. 2 × 10 ft. 8

Tension, Crushing, and Transverse Test Machines ; hand and power ; built :

Fig.	4	4	3
L =	60*t*	50*t*	50*t*
S =	10 ft. 10 × 15 ft. 5 × 11 ft. 5	10 ft. 10 × 9 ft. 10 × 12 ft. 9	10 ft. 1 × 13 ft. 3 × 8 ft. 10
Fig.	4	1	1
L =	30*t*	15*t*	10*t*
S =	10 ft. × 9 ft. 1 × 9 ft. 1	7 ft. 10 × 8 ft. 6 × 7 ft. 4	7 ft. 10 × 8 ft. 1 × 6 ft. 11

Tension Machines ; hand power ; built :

Fig.	7	7
L —	2200 lbs.	880 lbs.
S =	1 ft. 1 × 4 ft. 7 × 4 ft.	1 ft. 1 × 3 ft. 8 × 3 ft

Transverse Machines ; hydraulic power ; built:

Fig.	6	6	6
L =	80*t*	60*t*	40*t*
S =	4 ft. 7 × 8 ft. 10 × 7 ft. 4	4 ft. 7 × 8 ft. 2 × 7 ft. 1	4 ft. 7 × 7 ft. 6 × 7 ft.

Spring-testers; hydraulic power; built:

Fig.	2	2	2
$L =$	16t	20t	5t
$S =$	11 ft. 1 × 9 ft. 6 × 11 ft. 8	9 ft. × 9 ft. × 9 ft. 10	8 ft. 6 × 3 ft. 5 × 5 ft. 5

Transverse Machines for Cast Iron; hand power; built:

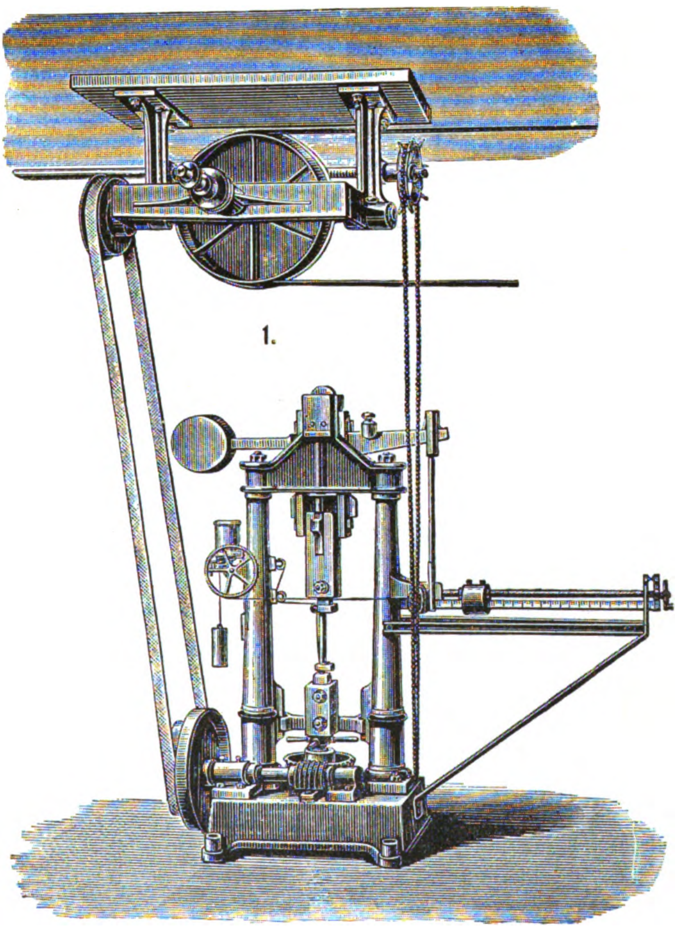
Fig.	8	8
$L =$	2200 lbs.	1320 lbs.
$S =$	1 ft. 9 × 4 ft. 1 × 3 ft.	1 ft. 9 × 4 ft. 1 × 3 ft.

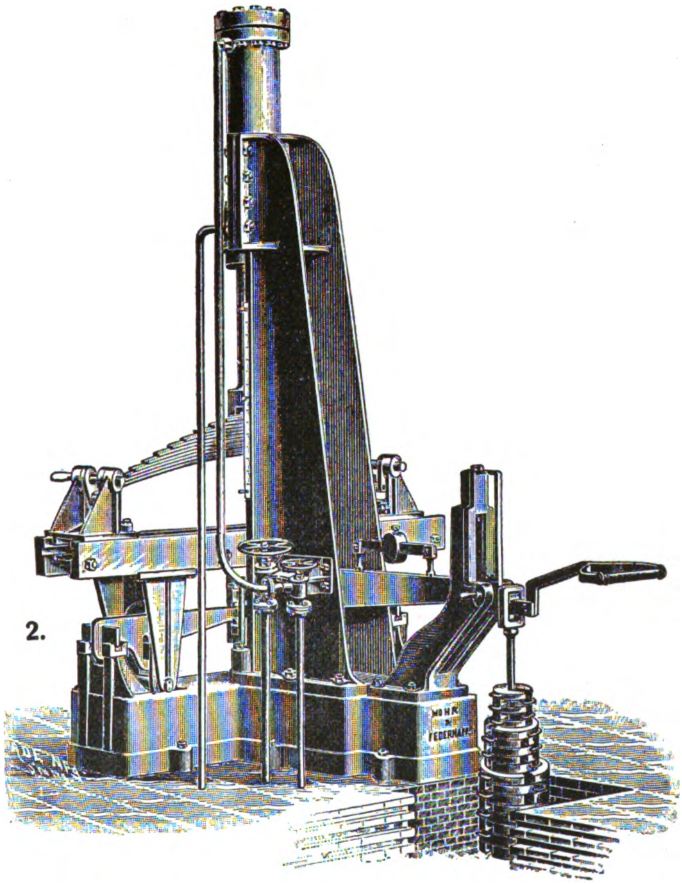
Wire-winding Machines; hand power; built like Fig. 12; $T. P. =$ 0.04 to 0.24 in. diam.; $S = 50'' \times 16'' \times 14''$; wt. 160 lbs.

Bending-test Machine for Sheet Metal; hand power; built like Fig. 9; $T. P.$: $S = 40'' \times 22'' \times 21''$; wt. = 450 lbs.

Bending-machines for Flats; built.

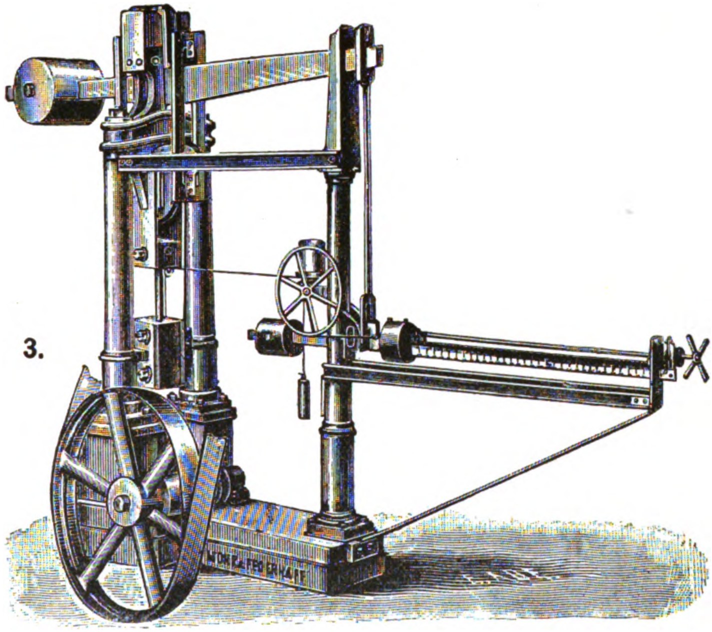
Fig.	10	11	
$T. P. =$	2 in. × 0.4 in.	2 in. × 1 in.	Fig. 10 for hand power.
$S =$	4 ft. 2 × 3 ft. × 1 ft. 5	4 ft 2 × 3 ft. × 1 ft. 10	Fig. 11 for hand and mechanical power.


1.

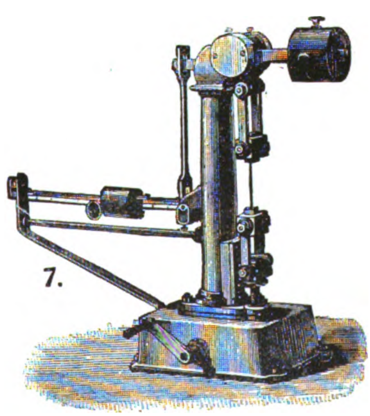


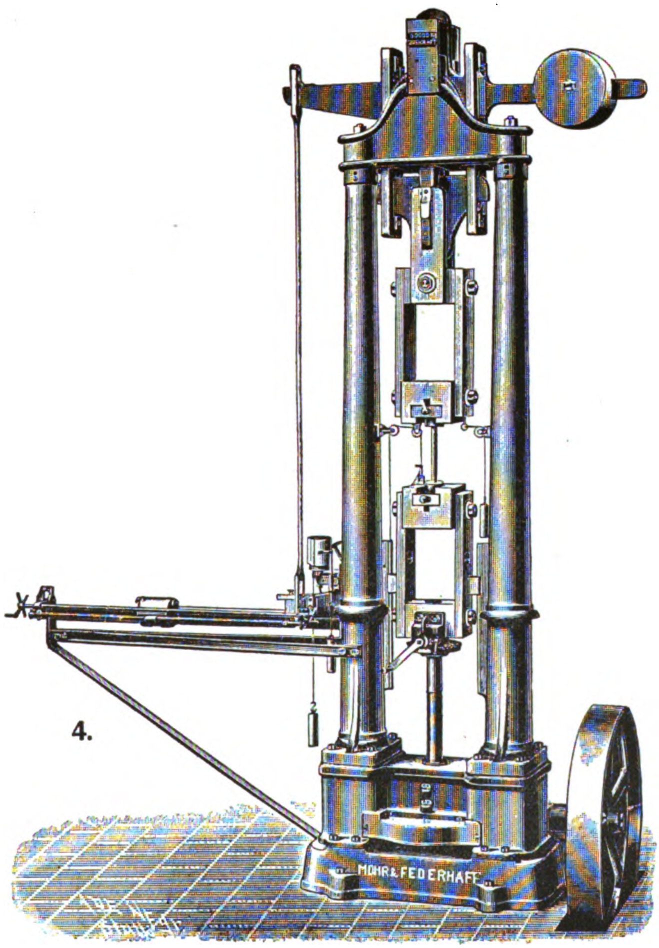
2.

3.

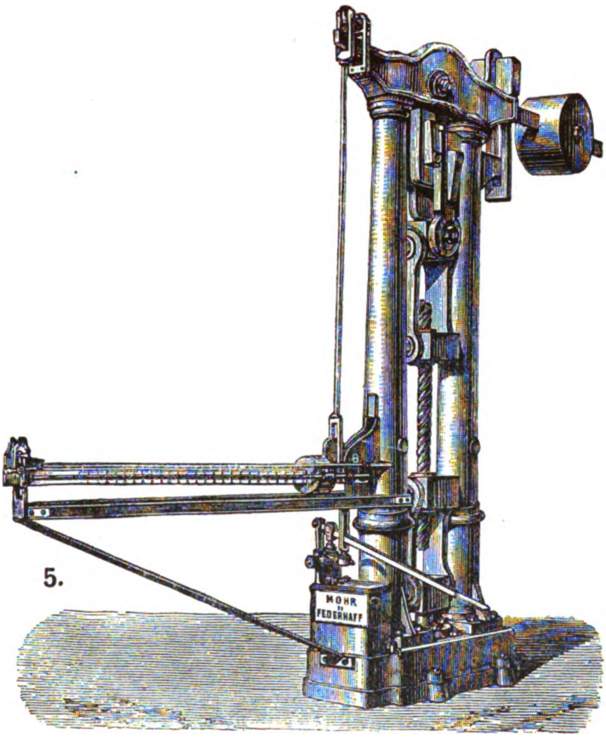


7.



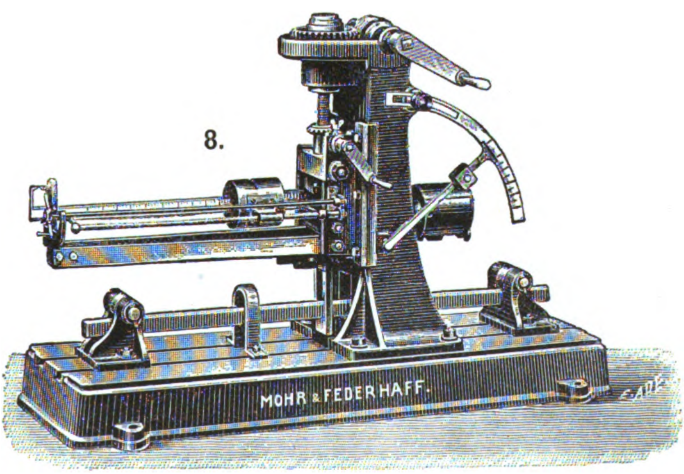


4.

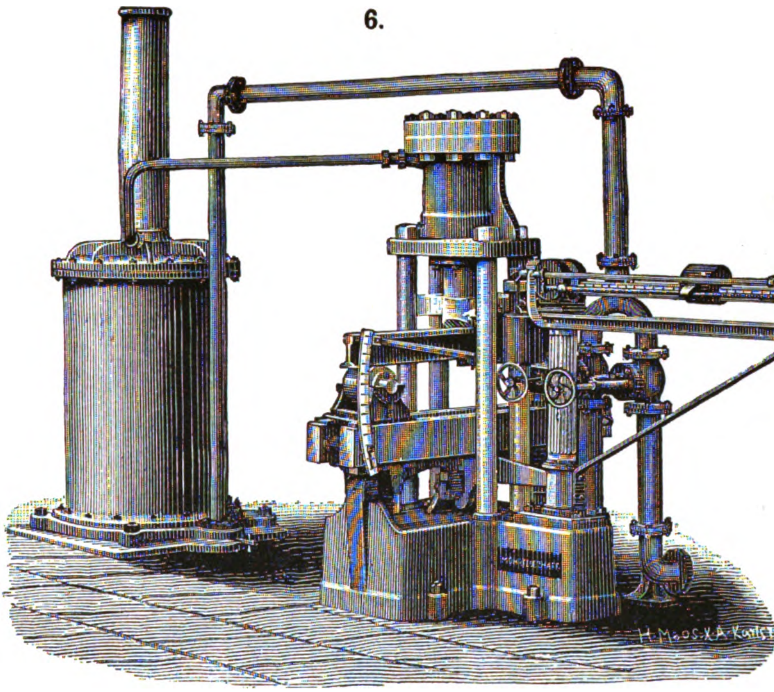


5.

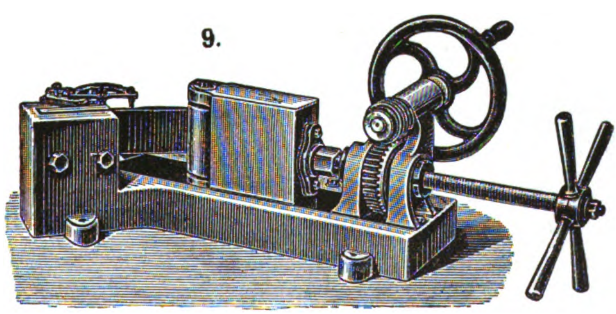
8.



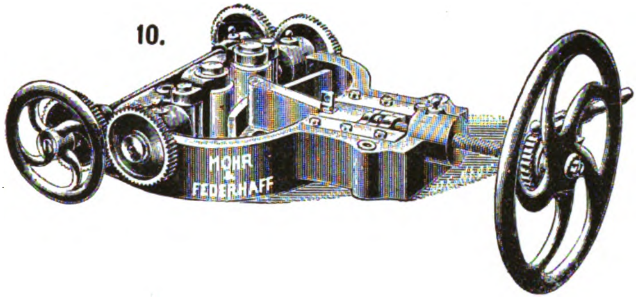
6.



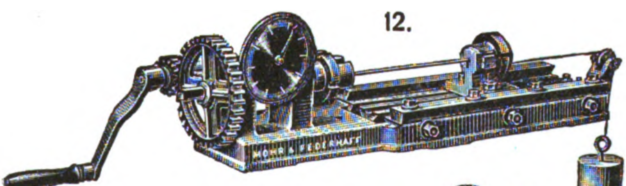
9.

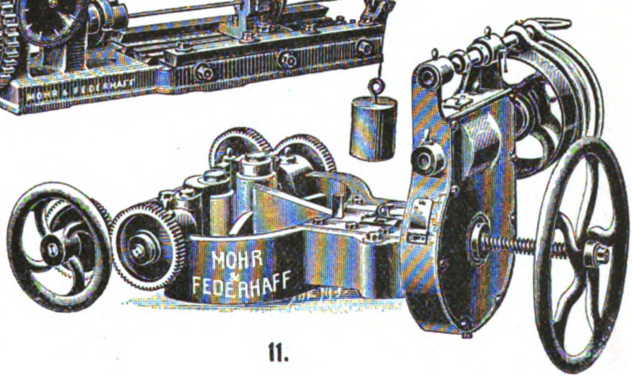


10.



12.





11.

EXPLANATIONS. **Plate 8.**

GRAFENSTADEN TESTING-MACHINES.

ALSATIAN MACHINE WORKS, GRAFENSTADEN, GERMANY.

Sects. 492, 493, 518, 583–586. (*L 12*, 1882, p. 8.)

S = space (length, breadth, height) in.

1-7. 50-ton Machine, tension, crushing, transverse tests. $S = 9$ ft. 1 × 5 ft. 3.

1. Elevation, tension-test of rounds.
2. Longitudinal section, tension-test of flats.
3. General view.

4–5. Arrangement for crushing-test.

6–7. Arrangement for transverse test.

8. Construction of Check-scale.

9. General View of 100-ton Machine. $S = 10$ ft. 10 × 6 ft. 10 × –

10. General View of 25-ton Machine. $S = 6$ ft. 7 × 4 ft. × —

11-22. Tension-holders for Rounds and Flats.

23-28. Shapes of Tension Test-pieces.

29, 30. Recording Apparatus.

EXPLANATIONS. **Plate 9.**

50-TON (50.000-KG.) POHLMEYER TESTING-MACHINE.

DESIGNED BY V. POHLMEYER, 1879. BUILT BY H. EHRHARDT, ZELLA, ST. BLASII, GERMANY.

Sects. 465, 493, 532, 533, 534 *a–e*, 587–590. (*L* 229.)

1-8. 50-ton Pohlmeyer Machine.

Machines are built for $L = 25$, 50, and 100 tons.

1, 2. Longitudinal section and elevation.

3, 4. Plans.

5–8. Crushing-test platens.

9–14. Safety devices of knife-edges.

15–18. Transverse-test holders.

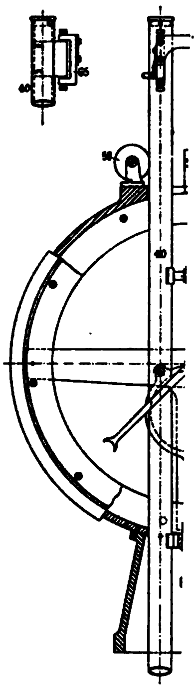
19-27. Details of Recording Apparatus (Martens').

28, 29. *Hand pump.*

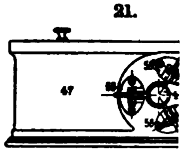
30, 31. Intensifier for city pressure.

Designation of detail: 80, main; 73, valve-chamber; 79, feed to main cylinder; 78, to small cylinder; 77, to the machine; 75, safety and outlet valve; 81, outlet.

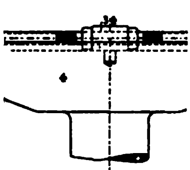
22. 19.



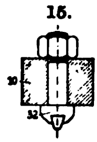
21.



16.



15.



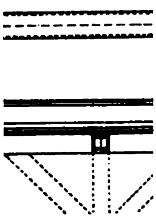
EXPLANATIONS. **Plate 10.**

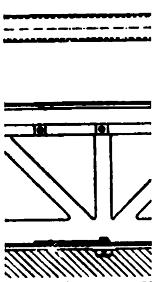
500-TON (500,000-KG.) TESTING-MACHINE.

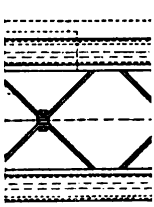
BUILT FOR THE CHARLOTTENBURG TESTING LABORATORY BY C. HOPPE BERLIN, GERMANY.

Sects. 189, 457, 493, 591–598.

1. Plan and section through press-cylinder.
2. Longitudinal section of machine.
3. Elevation.
4. Section in front of scale.
5. Buffers.
6. Crosshead of press.
7. Section at piston.
8. Section through press-cylinder.







EXPLANATIONS. **Plate 11.**

MACHINES OF

HARTIG-REUSCH, BUILT BY O. LEUNER, DRESDEN.
WENDLER, " " FROMME, BERLIN.
SCHOPPER, " " L. SCHOPPER, LEIPSIC.
LEUNER.

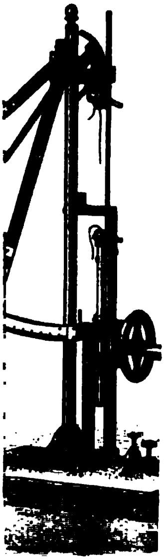
Secis. 482, 539, 540, 542–545 (*L 215*), 539, 543 (*L 215*), 536, 531, 543 (*L 228*).

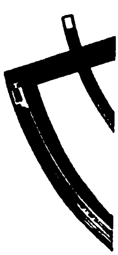
1-8. Schopper's Machine, for tests of thread, paper, etc., etc.
L = 20 lbs. to 1 ton.

9-13. Hartig-Reusch Machine, for tests of thread, paper, etc., etc.
L = 8-41 lbs.; for larger capacity built of somewhat different design.

14-27. Wendler's Machine (Martens' release) for paper tension-test.
L = 19-44 lbs.

28-49. Leuner Machine, for tension, crushing, and transverse tests.
L = up to 1 ton.





EXPLANATIONS. Plate 12.

MARTENS' IMPACT MACHINES. 1885–1896.

BUILT BY E. BECKER, BERLIN, AND BY THE CHARLOTTENBURG TESTING LABORATORY SHOPS.

Sects. 228, 229, 230, 232. (*L 100, 153, 155.*)

1-21. Machines for Impact-, Crushing-, Tension-, and Transverse-tests.

Drop up to 14 ft. 10. in.

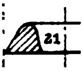
1, 2. Elevation and section.
3. Plan.
4, 5. Movable scale (clamp).
6–13. Balls (66–440-lbs.).
14–17. Dies (for flanging-test).
18–21. Arrangements for tension-tests.

22-30. Impact Machines for Tests of Flags, Pasteboard, Glass, etc.

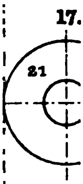
With balls of from 1–11 lbs.; drop up to 6½ ft.

31-35. Machine for Repetitive Impact-tests of Ropes, Chains, Ballast, etc.

16.

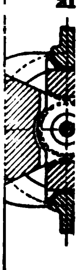


17.



19.

21



EXPLANATIONS. **Plate 13.**

TESTING-MACHINES OF

GOLLNER, BUILT BY F. J. MUELLER, PRAG.
PFAFF, " " R. FERNAN & CO., VIENNA.
MARTENS, " " CHARLOTTENBURG TESTING LABORATORY SHOPS.

Sects. 598–601 ; 452, 479, 490, 493. (L 220).

1-14. Gollner Machine. $L = 20$ tons.

1. Elevation.
2. Section.
3. Power-pump.
4. Arrangement for transverse tests ; section.
5. Arrangement for torsion-tests ; elevation.
6. Plan of machine.

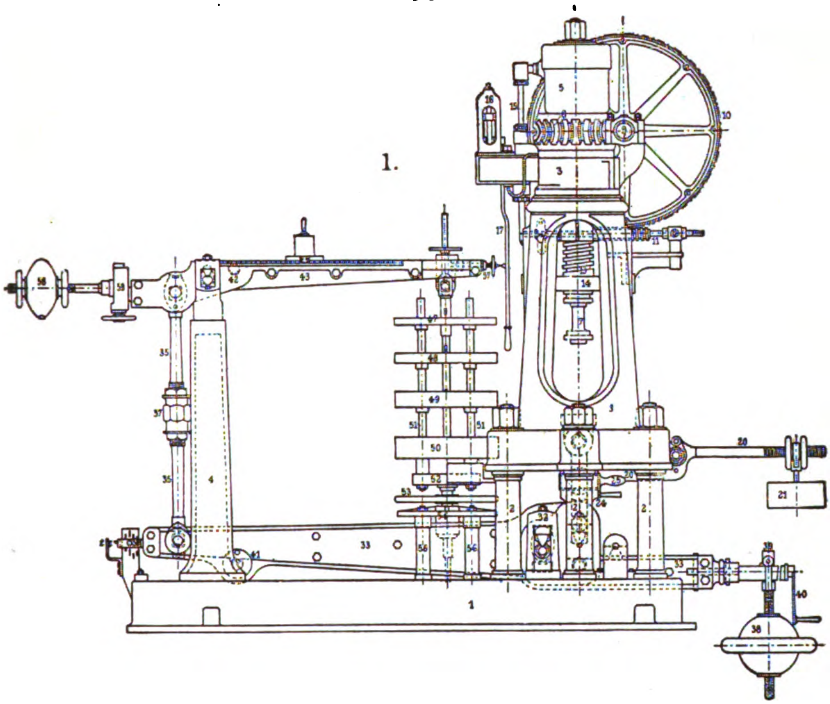
7–9. Tension-holders.
10–14. Crushing-holders.

15-17. Pfaff Machine. $L = 70$ tons. Elevation, section, and plan.

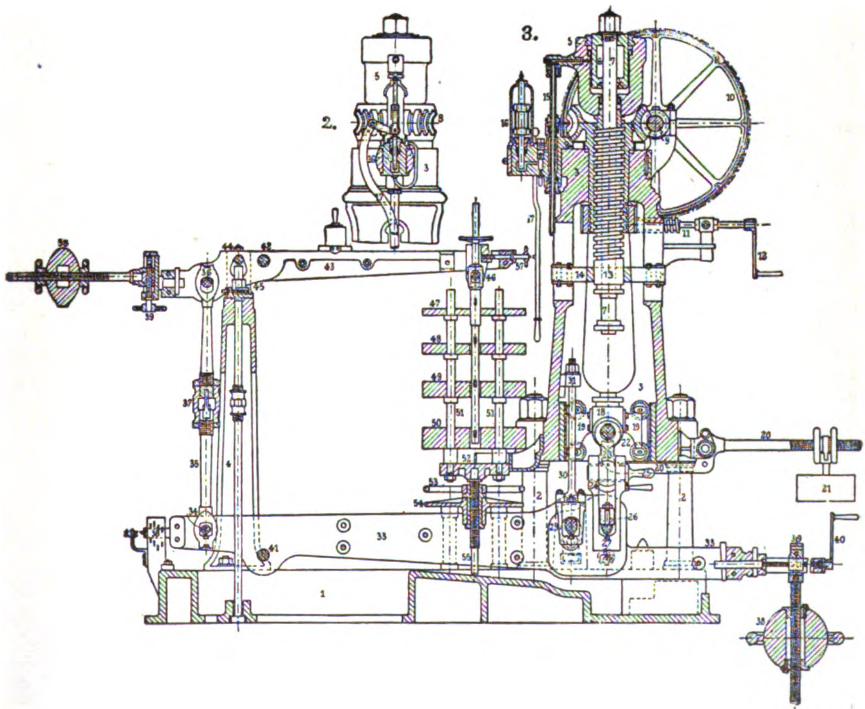
18-31. Martens' 5-ton Machine.

18–20. General views.
21–31. Detail.

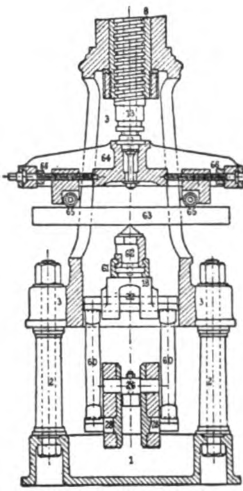
1.



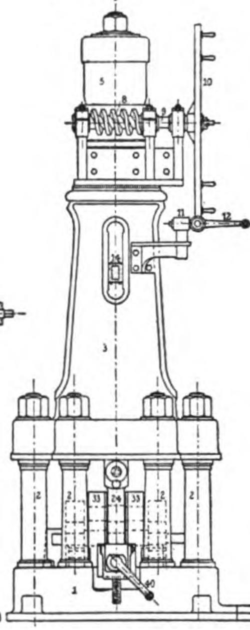
2. 3.



4.

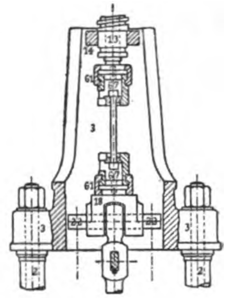


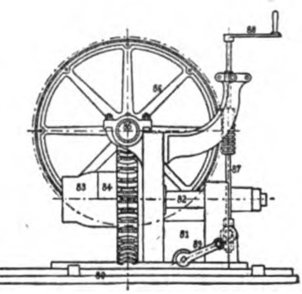
5.

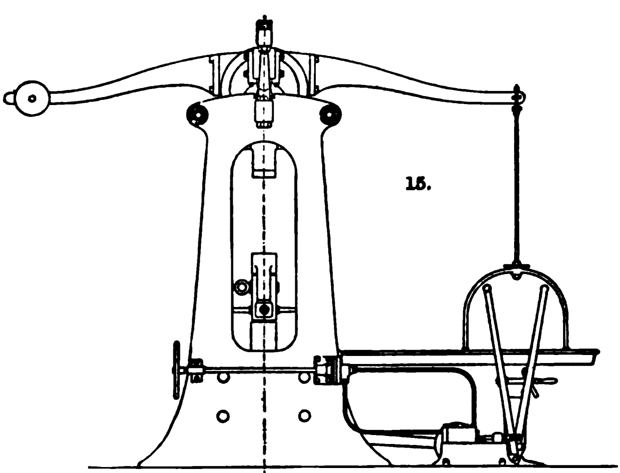


7.

8.

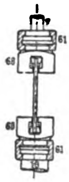




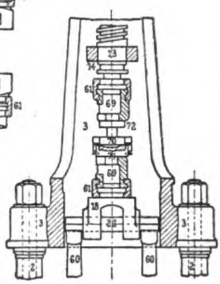


15.

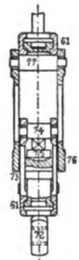
9.



10.

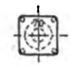


11.

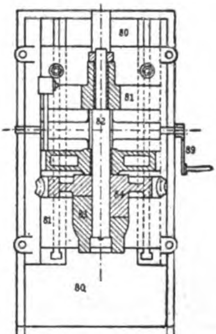


13.

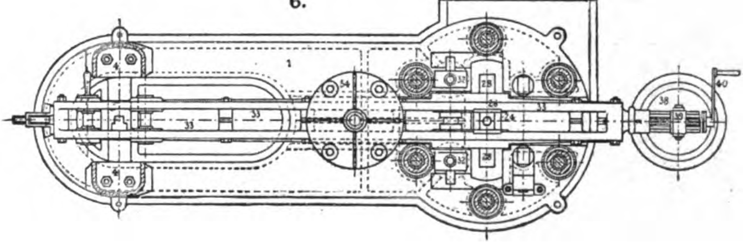
14.



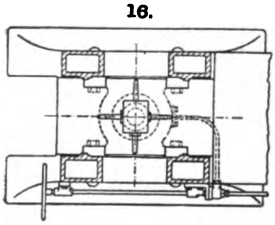
12.



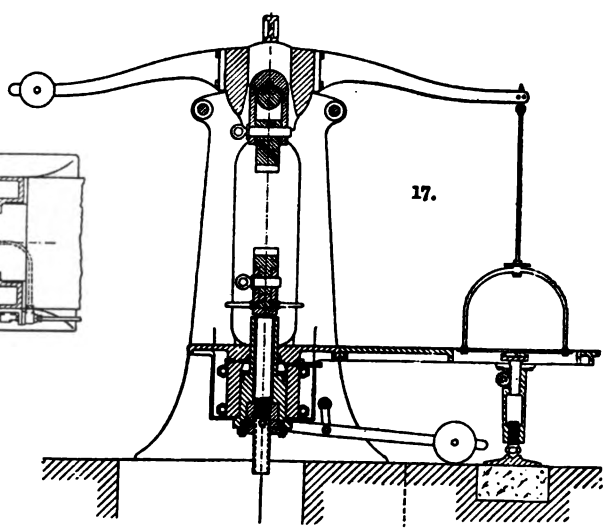
6.

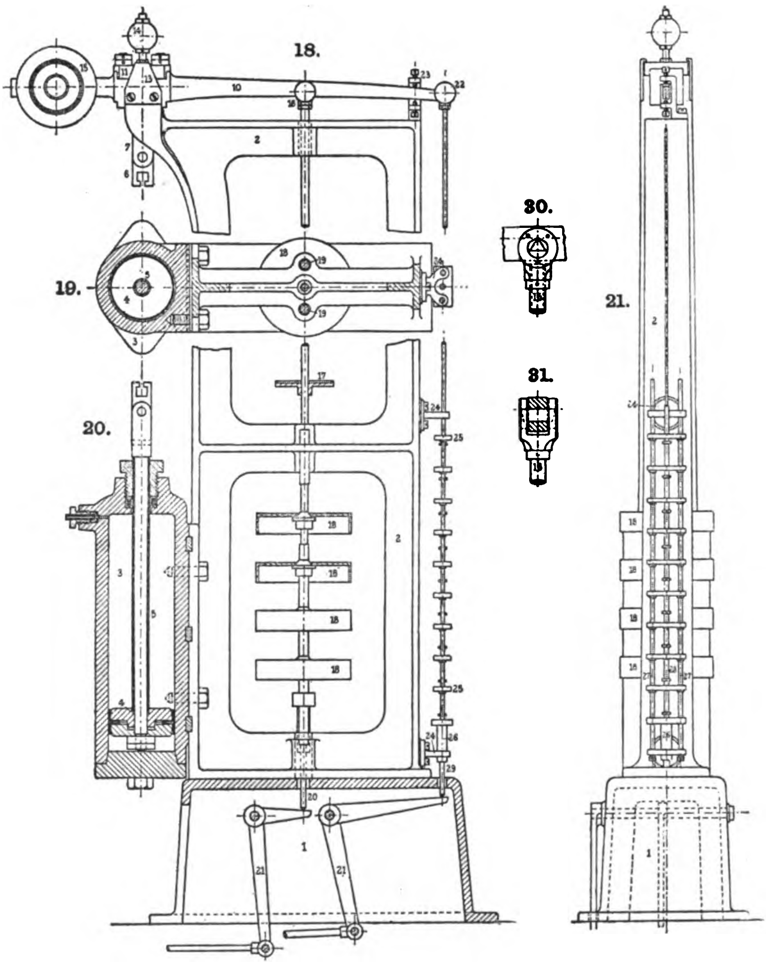


16.

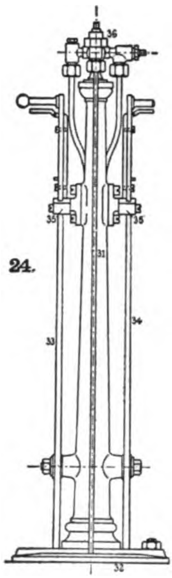


17.

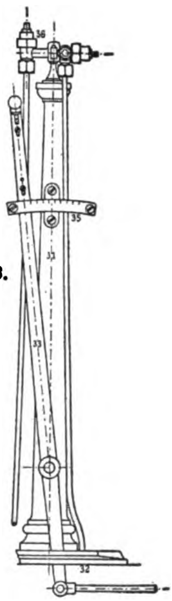



18.
19.
20.
21.
30.
31.

24.

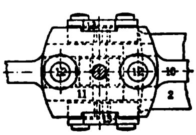


23.

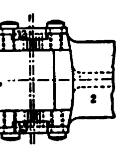


22.

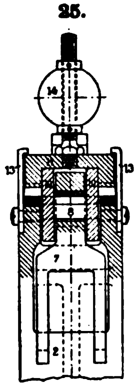
26.



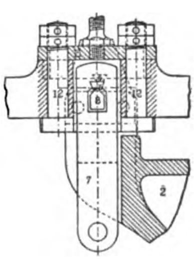
29.



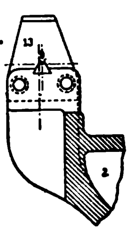
25.



27.



28.



EXPLANATIONS. Plate 14.

AMSLER-LAFFON TESTING-MACHINES,

SCHAFFHAUSEN, SWITZERLAND.

Sects. 602–609, 453, 477, 550, 561. (*L 3*).

1. Crushing- and Transverse-test Machine. $L = 2$ tons; $S = 25\frac{1}{2} \times 23\frac{1}{2} \times 88\frac{1}{2}$; $T. P. = 13 \times 8\frac{3}{4} \times 4\frac{3}{4}$ in.

2. Machine for Simultaneous Tension and Torsion. $L = 25$ t.; torsional moment $= 8400$ in. lbs.; $S = 47 \times 47 \times 130$ in.

3. Crushing-test Machine (cement and mortar). $L = 33$; $S = 31 \times 31 \times 82\frac{3}{4}$ in.

4. Tension Wire-tester. $L = 30$ t.; $S = 25\frac{1}{2} \times 27\frac{1}{2} \times 94\frac{1}{2}$; $T. P. = 21\frac{3}{4}$ *l.*; $d. = \frac{5}{16}$ in.

5. Tension-machine; for hand and power. $L = 25$ t.; $S = 25\frac{1}{2} \times 39\frac{1}{2} \times 118\frac{1}{2}$ in.

6. Tension-, Crushing-, Transverse-power Machine. $L = 50$ t.; $S = 39\frac{1}{2} \times 29\frac{1}{2} \times 118$ in.; $S_1 = 37\frac{1}{2} \times 35\frac{1}{2}$ in.

7. Crushing- and Transverse-test Machine. $L = 60$ t.; $S = 39\frac{1}{2} \times 31 \times 86\frac{1}{2}$ in.; $T. P. = 9\frac{3}{4} \times 7 \times 13\frac{1}{4}$ in.

8. Autographic Recorder for Tension, Crushing, and Deflection.

9. Crushing- and Transverse-test Machine. 50, 100 and 150 t.; $S = 36\frac{1}{4} \times 25\frac{3}{4} \times 160$ in. Pump $S_1 = 37\frac{1}{2} \times 35\frac{1}{2}$ in.

10. Torsional Wire-tester; $L = 335$ in. lbs.; $S = 41\frac{1}{4} \times 23\frac{1}{2} \times 47$ in.; $T. P. = l = 15\frac{3}{4}$ in.; $d. = 0.080 - 0.37$ in.

11. Wire-winding-test Machine. $S = 22 \times 4\frac{3}{4} \times 12$ in.; $T. P. = l = 8''$; $d. = 0.080 - 0.27$ in.

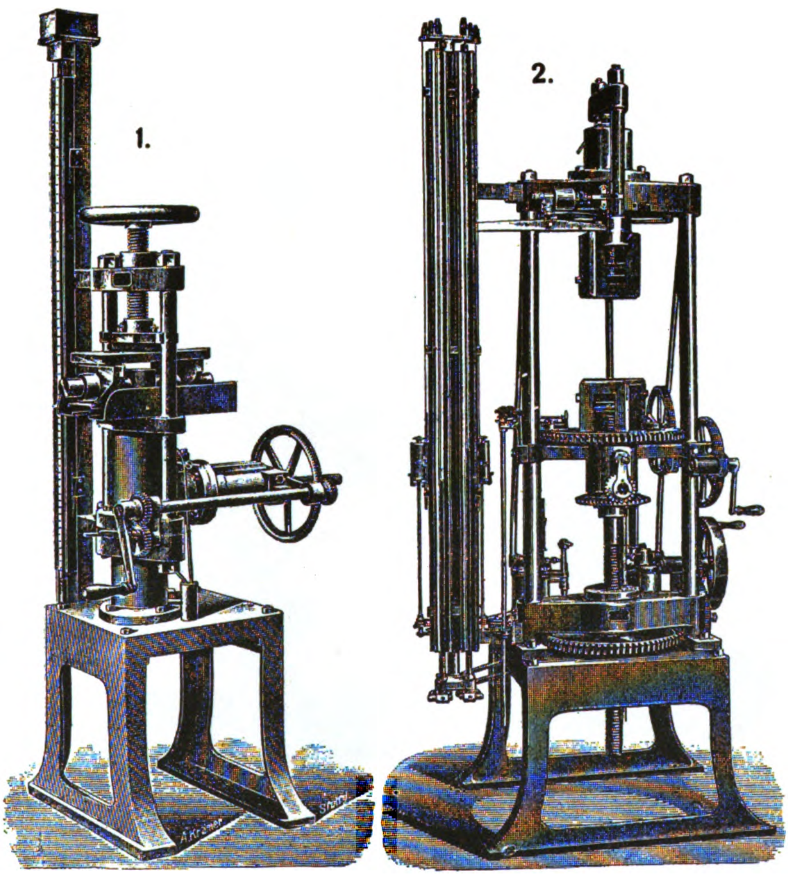
12. Crushing- and Transverse-test Machine. $L = 5$ t.; $S = 27\frac{1}{2} \times 25\frac{1}{2} \times 94\frac{1}{2}$ in.

13. Bending-test Machine. $L = 70$ t.; $S = 40 \times 25\frac{1}{2} \times 43$; $T. P. = 6\frac{1}{2} \times 2\frac{3}{8}$ in.

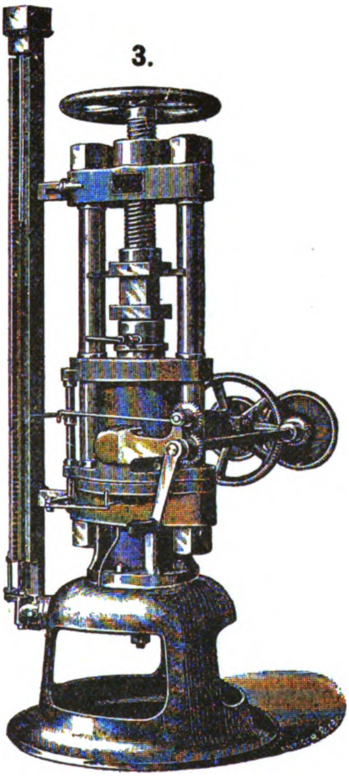
14. Circular Bending-test Machine. $L = 21{,}300$ in. lbs.; $S = 35\frac{1}{2} \times 27\frac{1}{2} \times 71$ in.; $T. P. = 4\frac{3}{4} \times 3\frac{1}{8} \times 0.8$ in.

15-20. Holders for Tension-test.

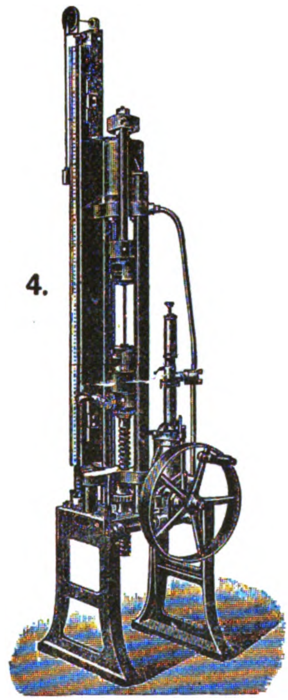
Plate 14. A.



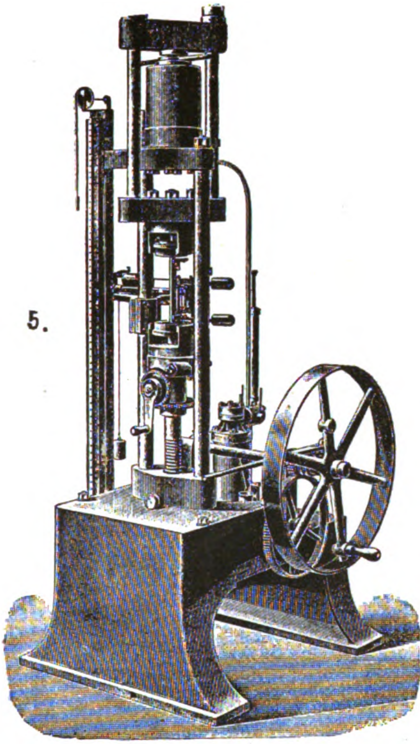
3.



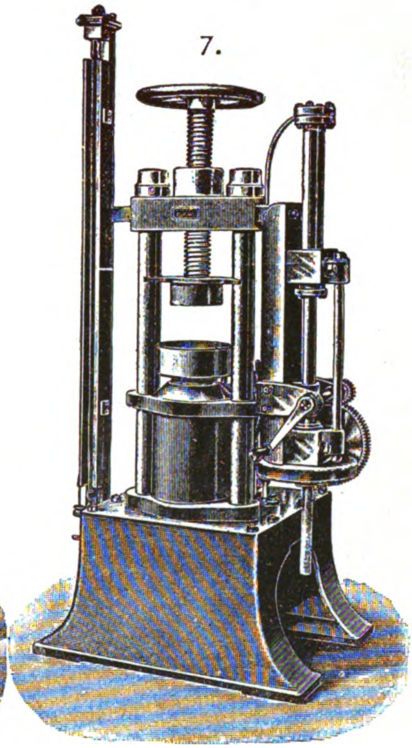
4.



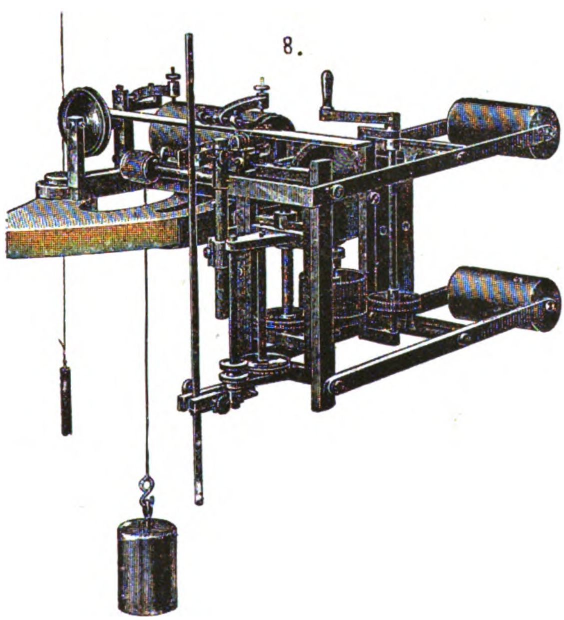
5.



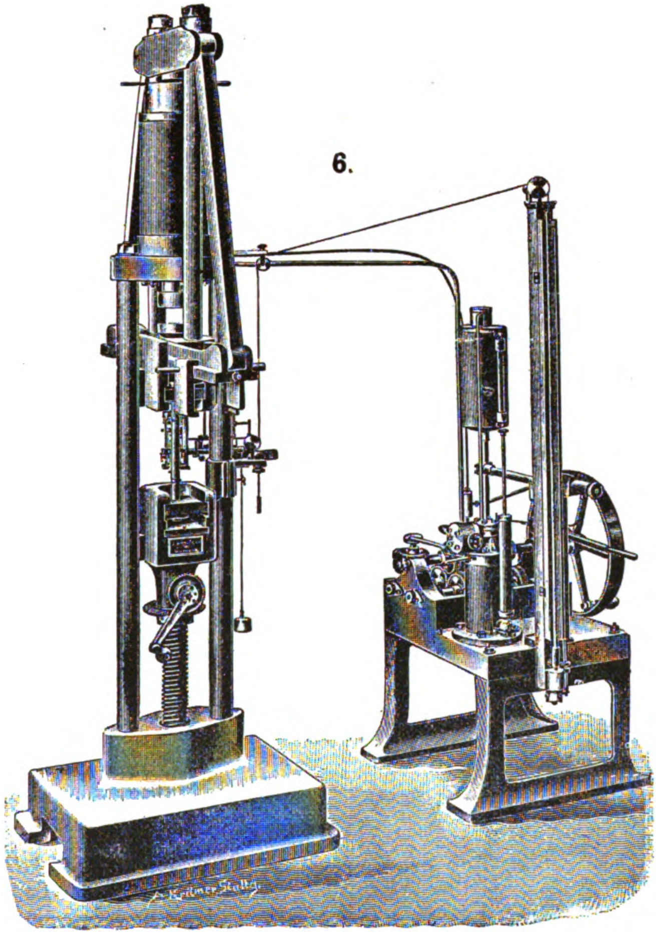
7.



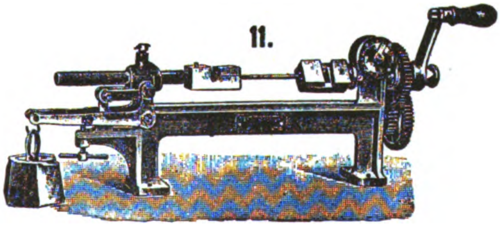
8.



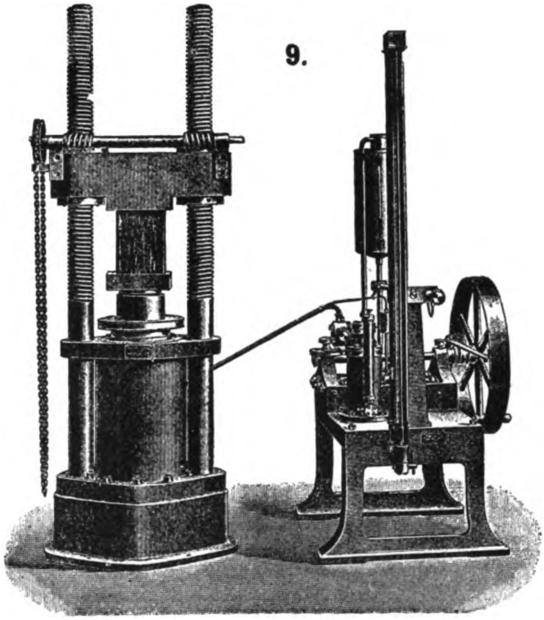
6.



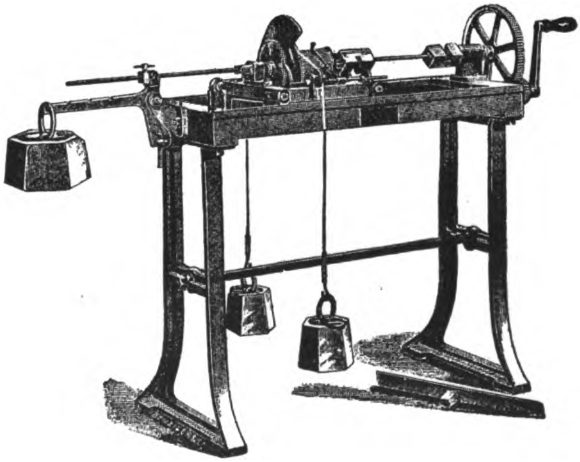
11.



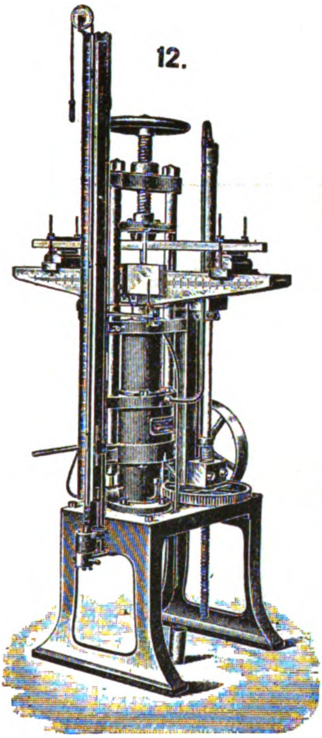
9.



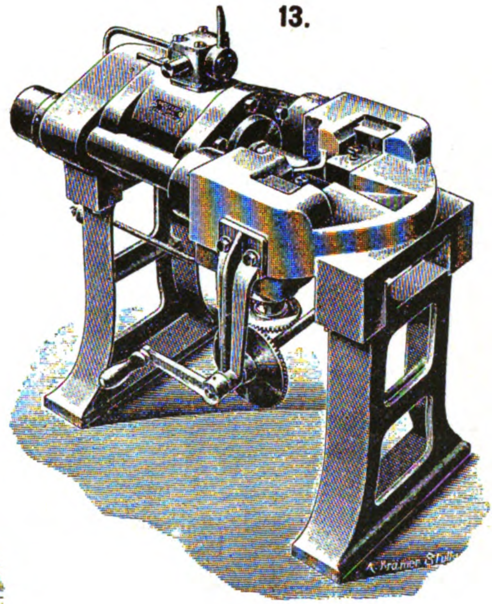
10.



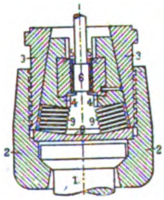
12.



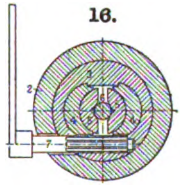
13.



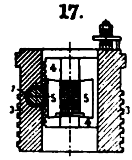
15.



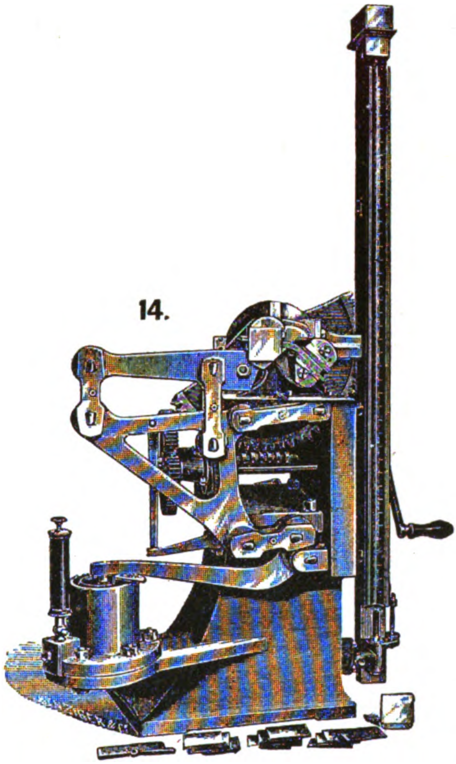
16.



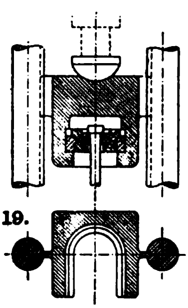
17.



14.

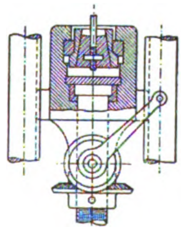


18.



19.

20.



EXPLANATIONS. **Plate 15.**

FRENCH TESTING-MACHINES.

Sect. 610.

1, 2. Marin-Darbel Machine; 65 lbs., 2, 5, 10, 15, 30, 60 and 100 tons. Small machines without levers.

3-5. Thomasset Machines; for torsion-tests.

6. Thomasset Machines. $L = 25$, 50 tons and less than 1 ton.

7. Le Creusot Machines.

8-11. Dynamometer of the Paris, Lyons & Mediterranean Ry. $L = 20$ tons.

12-14. Dynamometer of the P., L. & M. Ry. $L = 80$ tons.

15. St. Chamond Machine. $L = 50$ tons.

16. Desgoffes, Ollivier, Curioni Machines.

17, 18. Chain-tester of the P., L. & M. Ry.

19, 20. Delaloë Machine.

21, 22. B. Trayvou Machine, of the Mulatière, Lyons, Steel Works. $L = 10$, 25, 30, 35 and 40 tons.

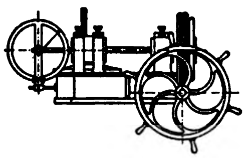
23. Maillard Machine. $L = 25$ tons.

24. E. Marié Machines of the P., L. & M. Ry. $L = 100$ tons.

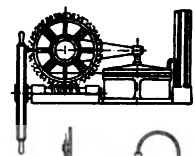
25. M. E. Petit Machine.

Bibliography to Figs.:
1, 2 . (*L 102, 183, 241*); **3-6** : (*L 183, 249*); **7** : (*L 102*); **8-14, 17, 18, 21, 22, 24** (*L 102, 183, 245*); **15** : (*L 102*); **16** : (*L 210*); **19, 20** : (*L 102, 183* ; *34*, 1888, p. 5); **23** : (*L 102, 183, 209*); **25** : (*L 102*).

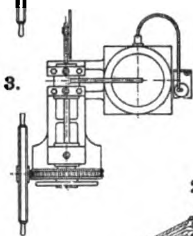
4.



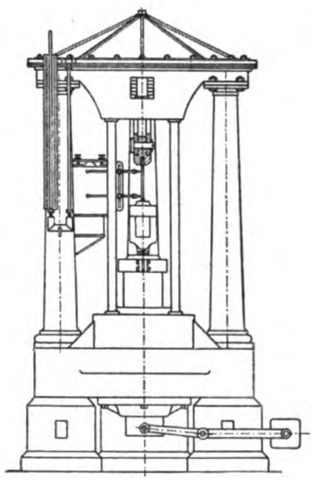
5.



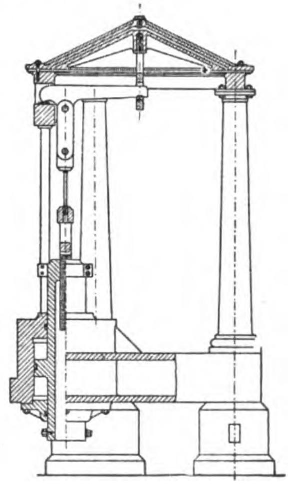
3.



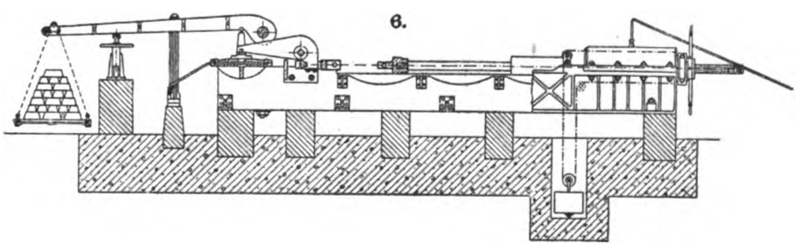
1.



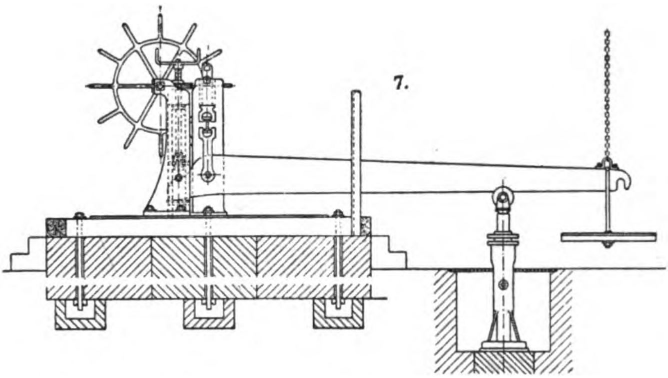
2.



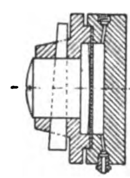
6.



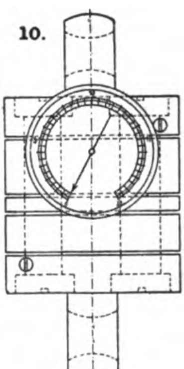
7.



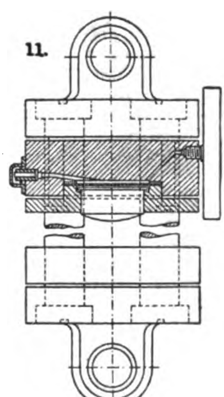
12.



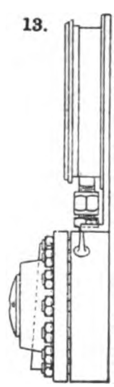
10.



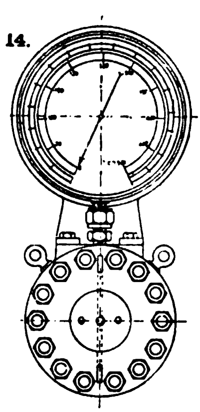
11.



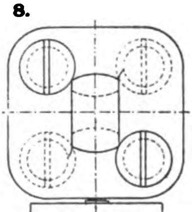
13.



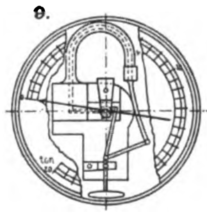
14.



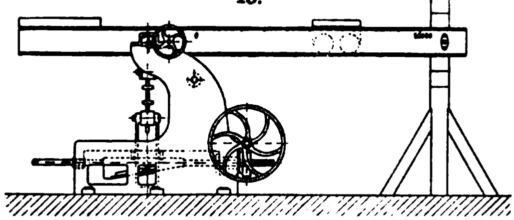
8.



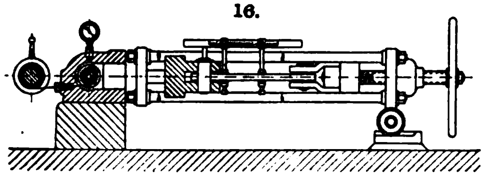
9.



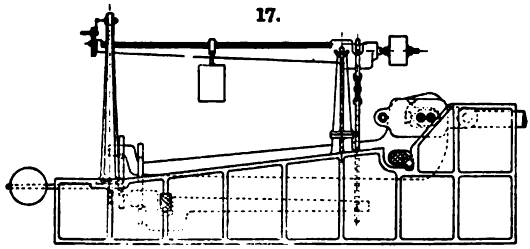
15.



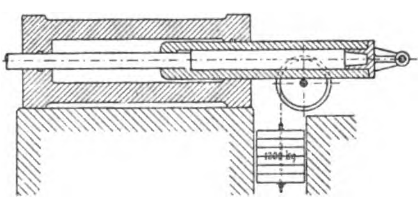
16.



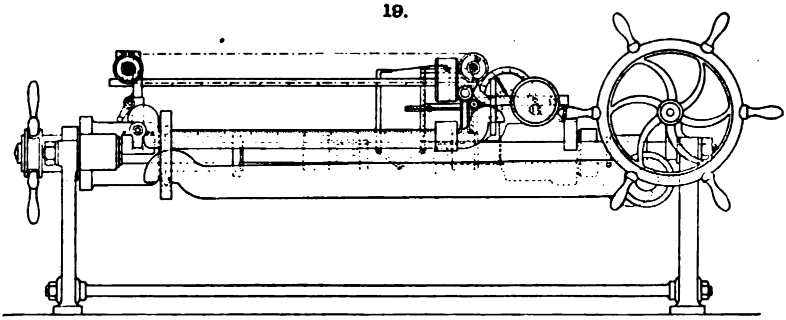
17.



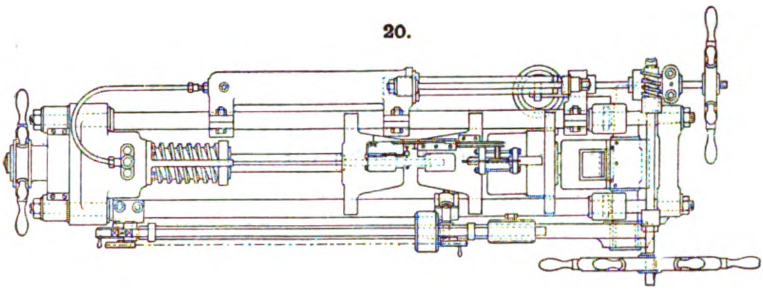
18.



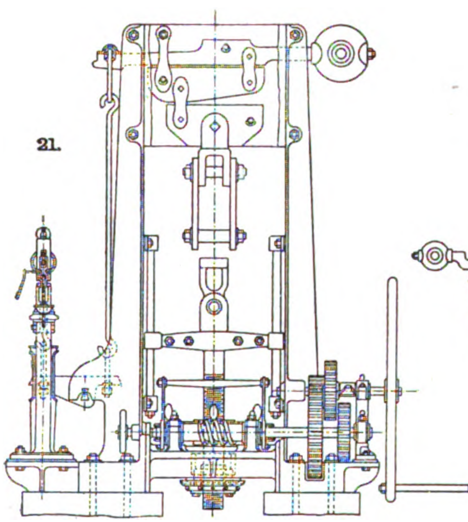
19.



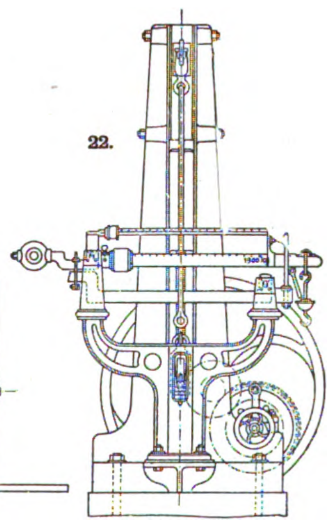
20.



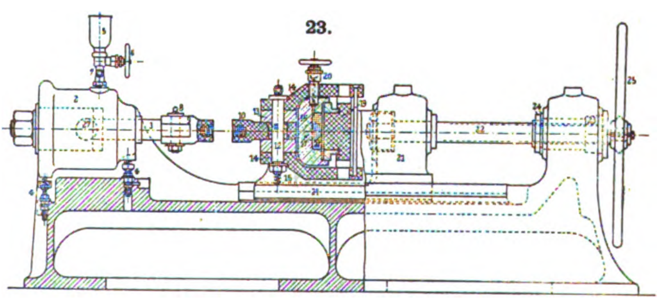
21.

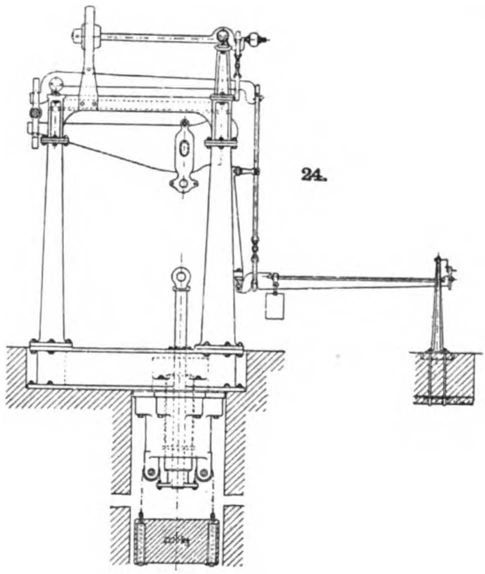


22.

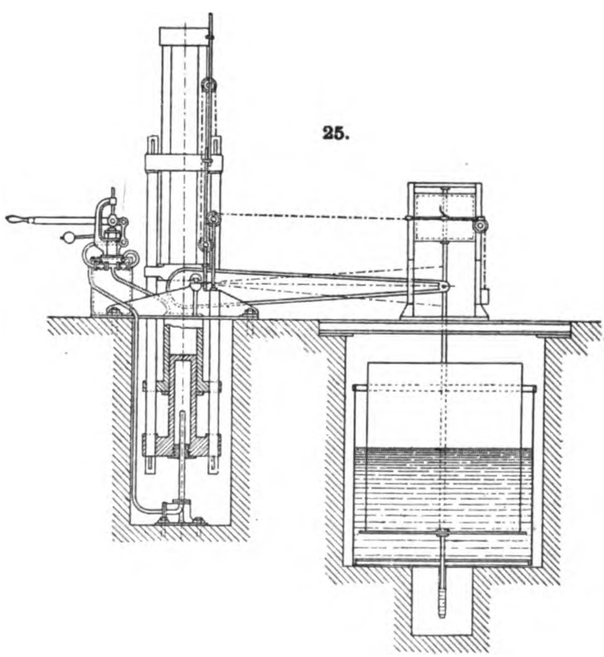


23.



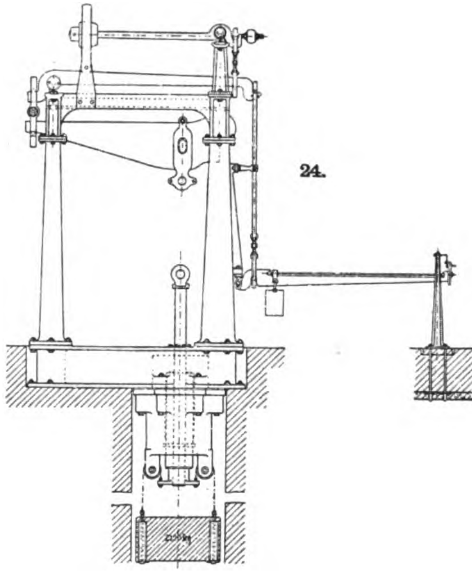


24.

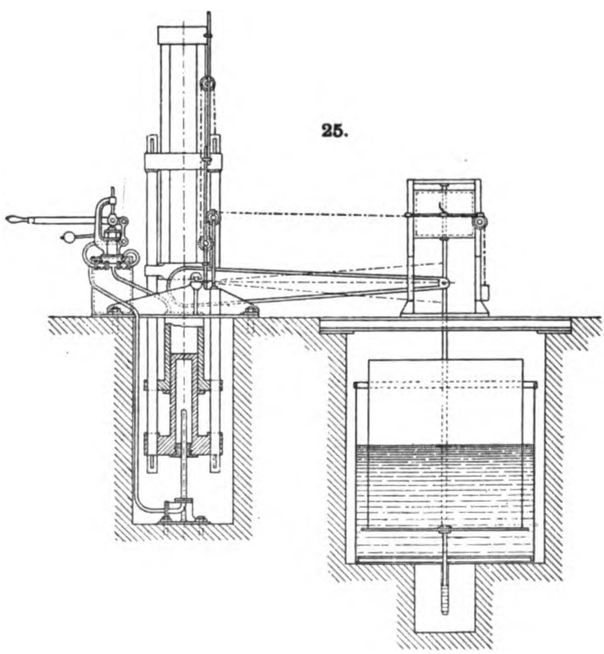


25.

24.



25.



EXPLANATIONS. Plate 16.

BRADFORD COLLEGE 100-TON (100,000-KG.) WICKSTEED MACHINE.

DESIGNED BY J. H. WICKSTEED. BUILT BY J. BUCKTON & CO. LIMITED, LEEDS, ENGLAND.

Sects. 611–618, 485 and 519, Pl. 16 and 17 (*L* *49*, 1884, p. 180; *45*, 1886, II. p. 27; *48*, 1886, II. p. 176; *243*).

1, 2. Arrangement for Thrust-test. $S = (l = 72$ in.; $t \times w = 9 \times 9$ in.).

3–5. Arrangement for Torsion-test. $L = 78{,}000$ in. lbs.; $S = (d = 2$ in.; $l = 12$ in.).

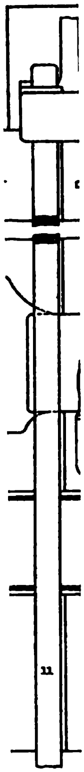
6, 7, 9. Arrangement for Transverse Test. $S = (l = 125$ in.; $w = 9$ in.; $n = 68$ in.

8, 10. Arrangement for Tension-test with Recorder. $S = 71$ in.

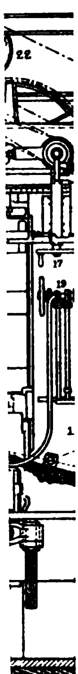
11, 12. Views and Arrangement of Machines. Vertical Machines:

Mach. No.	9, 10	8	7	6	5	4	3	2	1
$L =$	100 t.	60 t.	50 t.	30 t.	15 t.	10 t.	5 t.	2½ t.	.9 t.

Nos. 1, 2, for cement, wire, thread, or transverse tests of cast iron; No. 10 is a 4-column machine with cross-head; small machines are driven by screw-power; all machines can be arranged for tension, crushing, transverse, torsion and shearing-tests.



1.



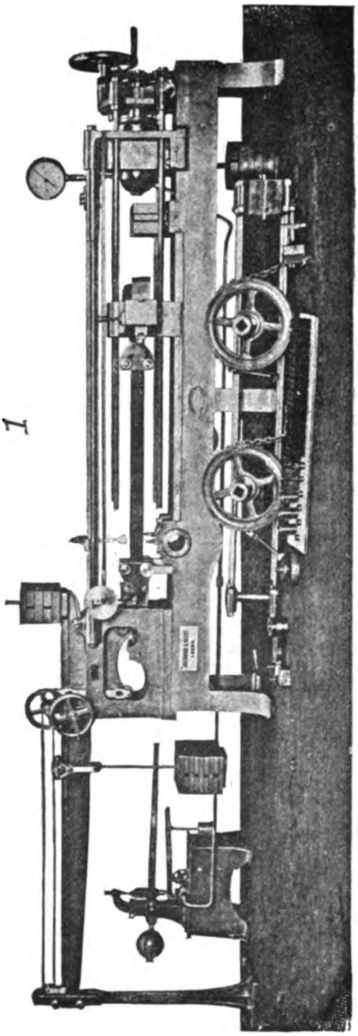
EXPLANATIONS. **Plate 17.**

1-6. Machines of Greenwood & Batley, Lim., Leeds, Eng. Sects. (619-622).

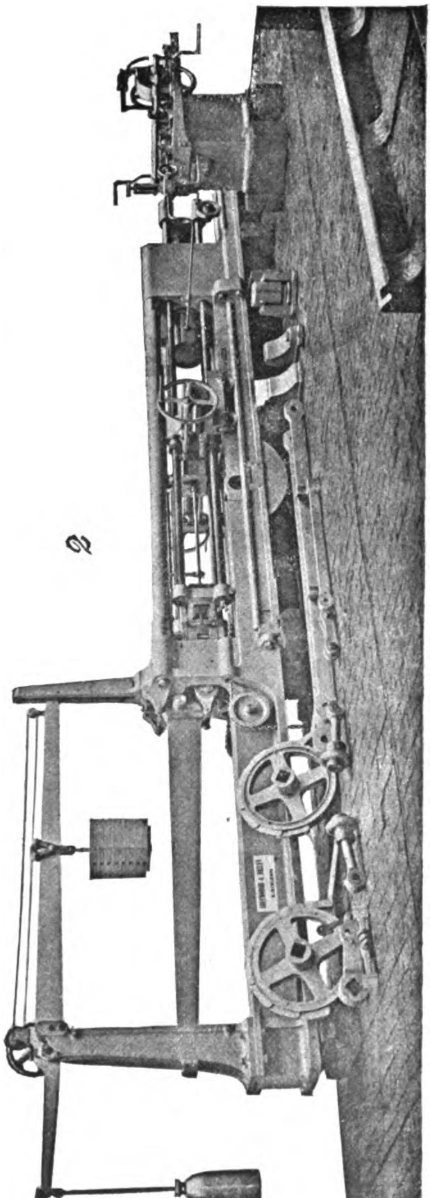
1. Machine for tension, crushing, bending, torsion, etc.
2. Machine for tension, crushing, bending, torsion, etc.
3. Vertical machine for wire, leather, cloth.
4. Movable chain-tester (without scale).
5. Wire-tester, for tension only. Also a similar machine of same capacity for tension and torsion.
6. Machine for testing wire, thread, textile fabrics, cement in tension.

7-10. Machines built by J. Buckton & Co., Lim., Leeds. Sects. 611-618.

7. Horizontal machine for tension, crushing, bending, torsion, without changing holders.
8. Vertical machine for tension, crushing, bending, torsion, shearing.
9. Vertical machine No. 4, arranged for torsion and transverse tests.
10. Duplex bending-machine No. 3; 10 strokes per minute; for bars of $1.8 \times 2 \times 1$ in.; made in three styles.

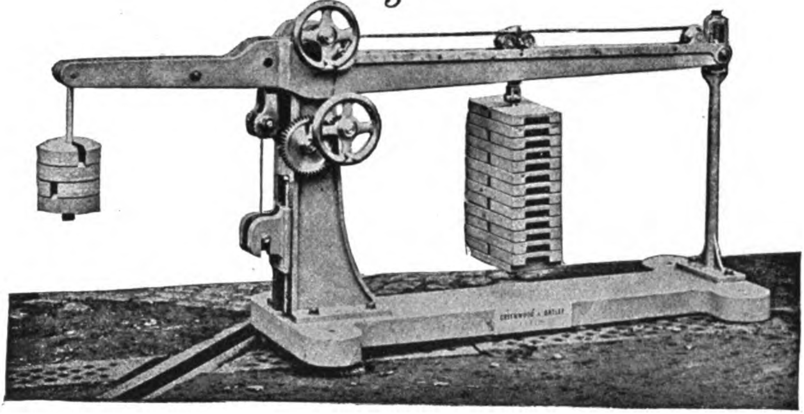


1

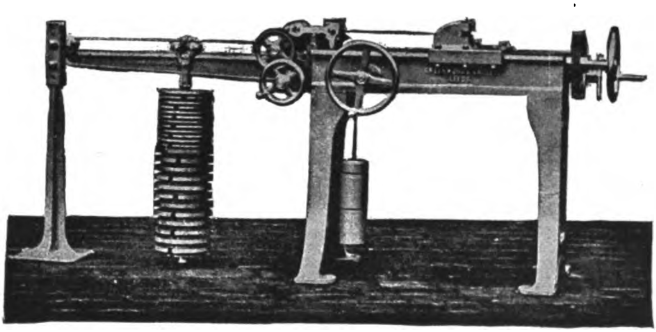


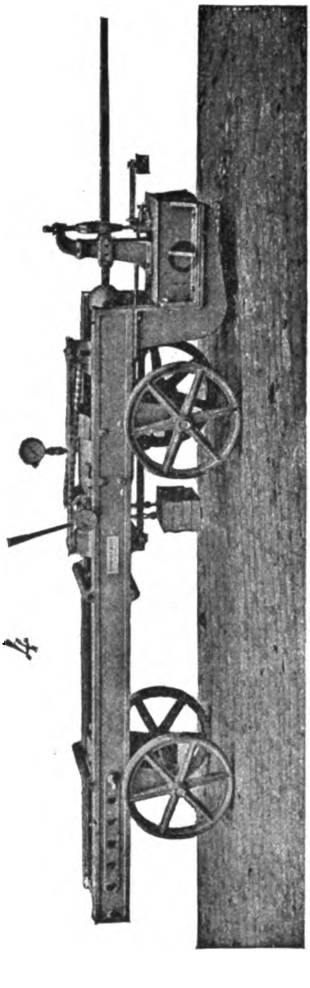
2

5

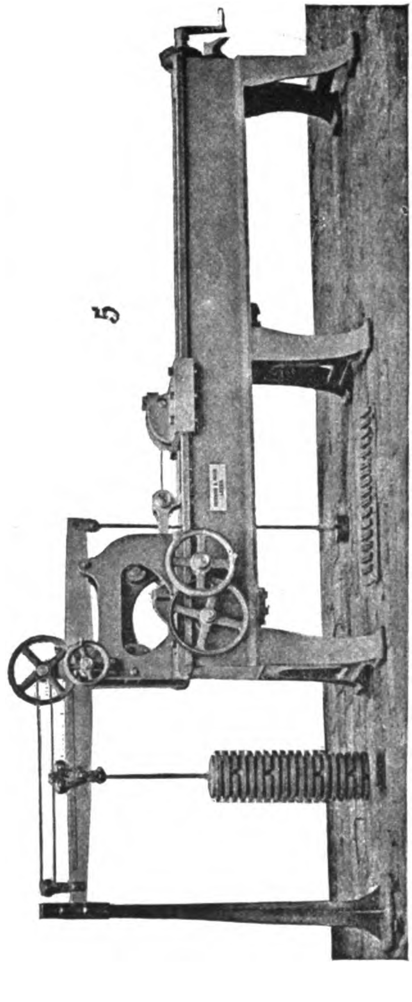


6



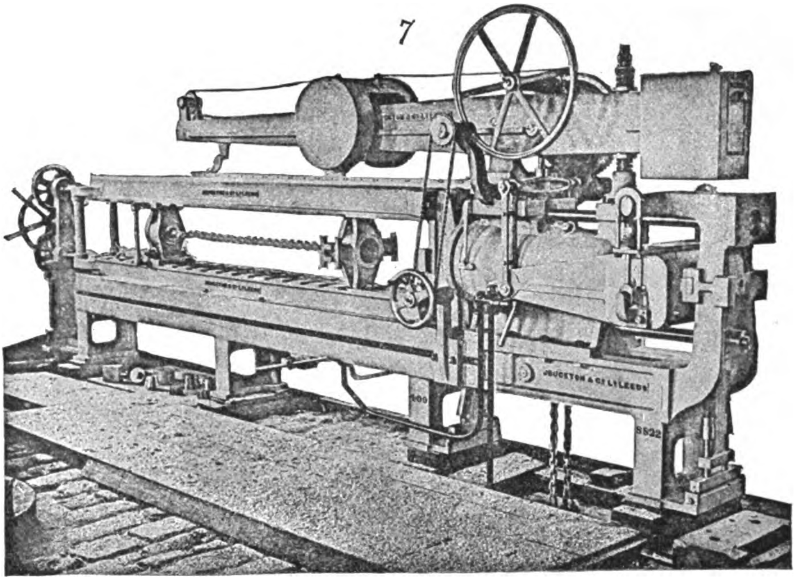


4

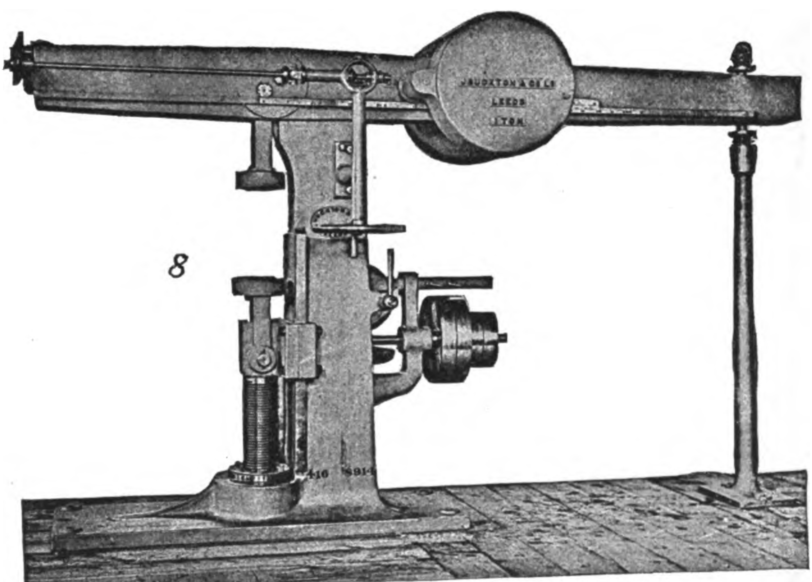


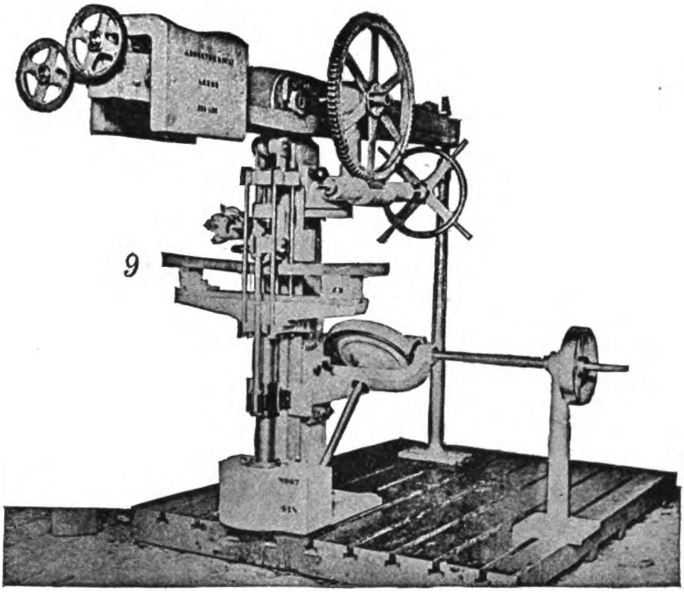
5

7



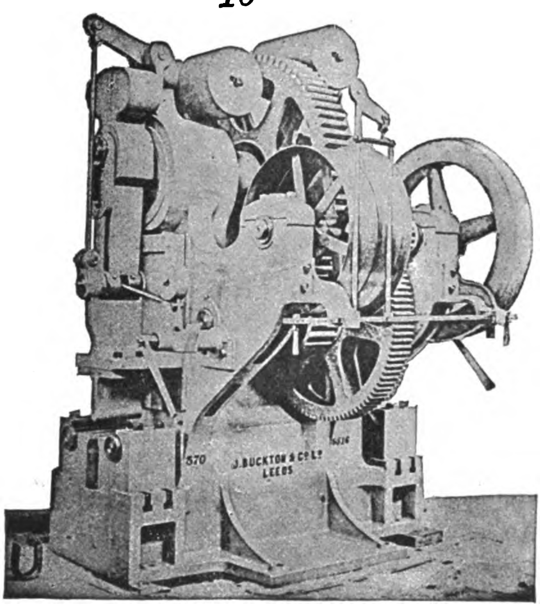
8





9

10



EXPLANATIONS. Plate 18.

150-TON (135,000-KG.) EMERY-SELLERS MACHINE.

DESIGNED AND BUILT BY WM. SELLERS & CO., PHILADELPHIA, PA.

Sects. 623-635, 483, 485, 501, 505, 559. (*L 211, 219, 242.*)

1-13. Load-indicator and Details.

1, 2. Vertical and horizontal sections. Support and initial straining-device ; guides of movable parts in the frames.

3. End view.

4–6. Support of initial straining-device.

7–11. Construction of supports.

12, 13. Construction of small chamber in scale-case.

14-18. Driving Mechanism and Details.

14–16. Views of power and adjustment.

17. Hydraulic press.

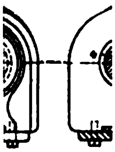
18. Gear-train for adjustment of 14–16.

19-33. Holders and Details.

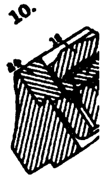
19–30, 32. Tension-holders.

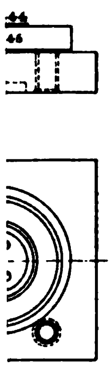
31, 32. Holders for crushing-test.

34, 35. Supporting-saddles.

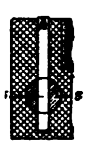


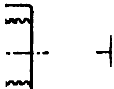
10.





24.





EXPLANATIONS. **Plate 19.**

RIEHLÉ TESTING-MACHINES AND APPARATUS.

DESIGNED AND BUILT BY RIEHLÉ BROS. TESTING-MACHINE CO., PHILADELPHIA, PA., U. S. A.

Sects. 636–639, 460, 526–528. (*L 51*, 1881, p. 147.)

1, 2. Power Machines for Tension, Crushing, and Transverse Tests; built:

Like Fig.	1	1	2	The machine may be operated at eight different straining-speeds = ⅛ in. to 7 in. per min.
$L =$	150 t.	100 t.	100 t.	
$S =$	11 × 4 × 20 ft.	——	11 × 4 × 8 ft. 6 in.	
T. P.	8 in. to 6 ft.	——	8 in. to 24 in.	

3. Power Machine for Tension Crushing, and Transverse Tests; built:

Like Fig.	3	In different sizes of capacities = 5 tons up to 150 tons, 5, 10, 15, 20, 25, 30, 50, 75, 100, and 150 tons, with six straining-speeds = 0.6 in. to 3½ in. per min.
$L =$	50 t.	
$S =$	6 × 9 ft. 3 in. × 2 ft. 9 in.	

4, 5. Power Machines for Tension, Crushing, and Transverse Tests. [Same as previous, but with automatic operation of poise.]

6. Power Machine for Torsion-tests. Capacity $L = 5000$ lbs.; $S = 3$ ft. 10 in. × 6 ft. 4 in. × 3 ft.

7, 8. Transverse-test Machine with Deflection-indicator for Cast Iron; built:

Like Fig.	7	8	8	Other types of these machines are also built.
$L =$	5000 lbs.	3000 lbs.	2400 lbs.	
$S =$	4 ft. 10 × 3 ft. 8 × 1 ft. 6	3 ft. 2 × 3 ft. 1 × 1 ft. 4	——	

9. Chain-testers; built for: $L = 25$ tons; Load-indicator $S = 6$ ft. 6 × 4 ft. 6 × 1 ft. 3; Driving Mechanism $S = 2$ ft. 6 × 2 ft. 6 × 2 ft.; length of chain up to 100 ft.; built of different type of capacity $L = 150$ tons.

10, 12, 17, 19. Power and Hand Spring-testers; built:

Like Fig.	17	12	12
$L=$	40 t.	5, 12½, 15 t.	15 t.
$S=$	8 ft. × 4 ft. 6 × 13 ft.	———	5 ft. 8 × 11 ft. × 5 ft.

Like Fig.	19*	19	10
$L=$	12½ t.	5 t.	2½ t.
$S=$	6 ft. 6 × 10 ft. × 5 ft. 2	6 ft. × 10 ft. 6 × 1 ft. 4	5 ft. × 6 ft. 4 × 2 ft. 4

Machine 19* is a pair of similar machines side by side. Machines 12, 17 and 19, hydraulic.

11. Tension, Crushing, Transverse Machine, hand-pump. $L=25$ t.; $S=8$ ft. × 7 ft. × 2 ft. 6 in.; *T. P.* 6 in. to 24 in.

13. Tension Machine. Hand-power, $L=10$ t.; $S=5$ ft. 9 × 7 ft. × 2 ft. 6.

14, 15, 16. Cloth-testers; built:

Like Fig.	14	15	15	16
$L=$	500 lbs.	500 lbs.	1000 lbs.	100 lbs.
$S=$	26 in. × 20 in. × 7½ in.	———	3 ft. 6 × 24 in. × 8 in.	26 in. × 25 in. × 8 in.

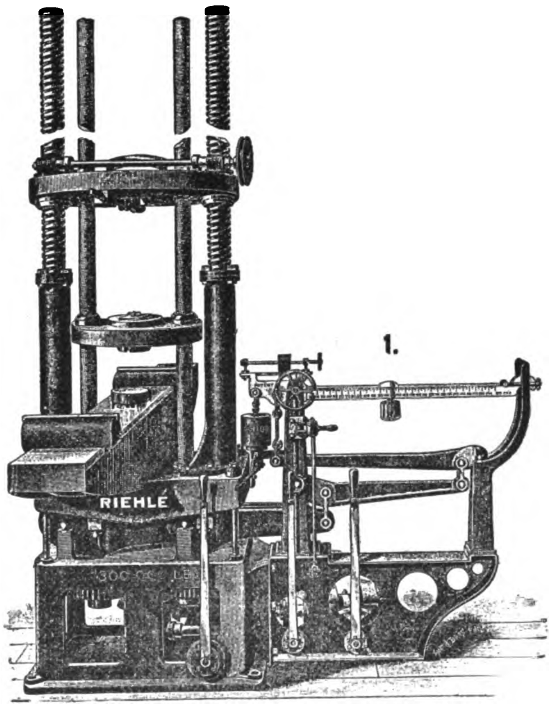
20. Cement-testers. $L=600$ lbs.; $S=38$ in. × 16 in. × 15 in.; is also constructed with travelling-poise.

21. Paper-tester. $L=100$ lbs.; $S=24$ in. × 12 in. × 12 in.

16, 26-31. Details of Recorders of various kinds.

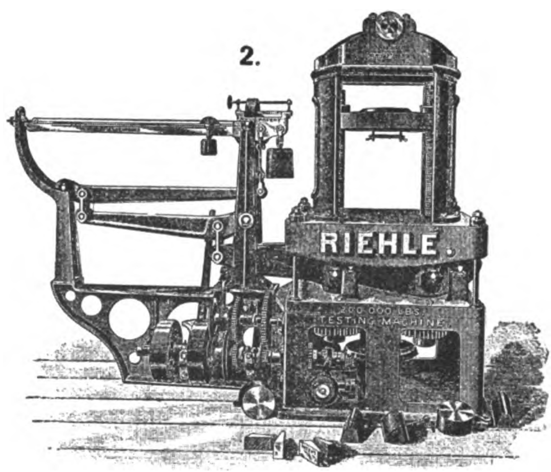
Fig. 18. Lever-system for multiplying extension; Figs. 26, 30. Record by poise; Figs. 27–29. Details thereof; Fig. 31. Another recorder.

22-25. Holders; and Fig. 22. Shape of Cast-iron Test-piece.

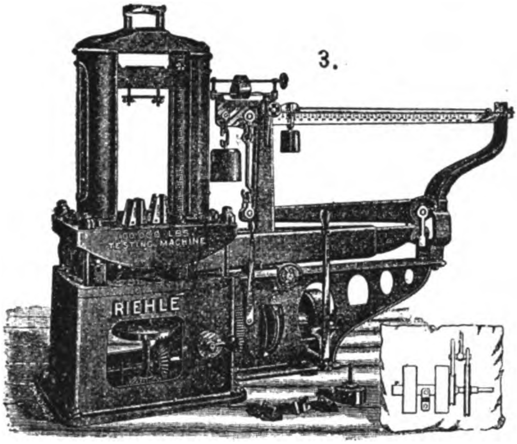


1.

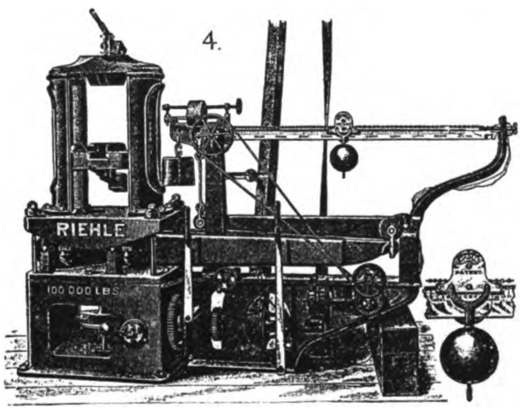
2.



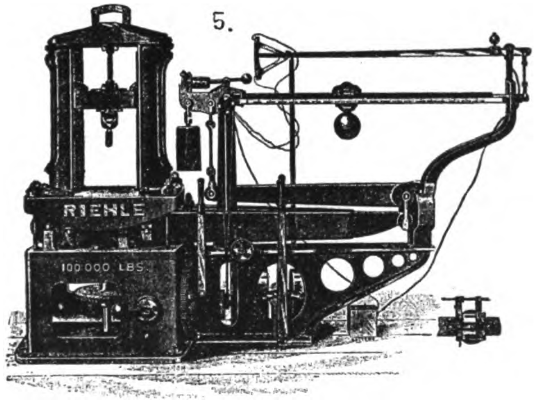
3.


100 000 LBS.
TESTING MACHINE
RIEHLE

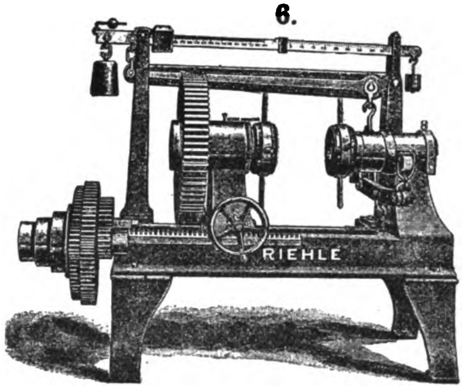
4.


RIEHLE
100 000 LBS.

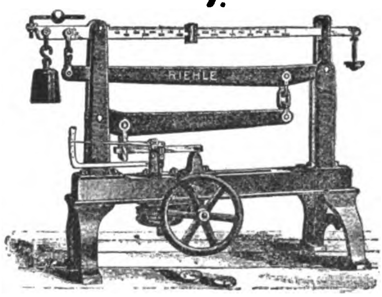
5.


RIEHLE
100 000 LBS.

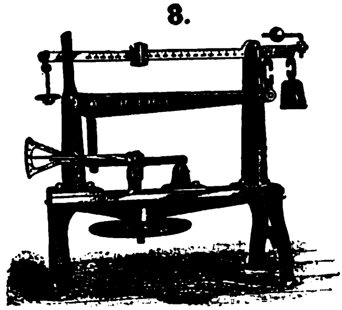
6.



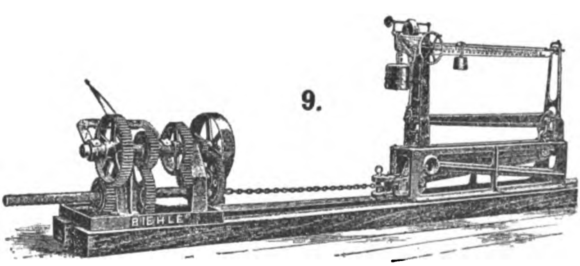
7.



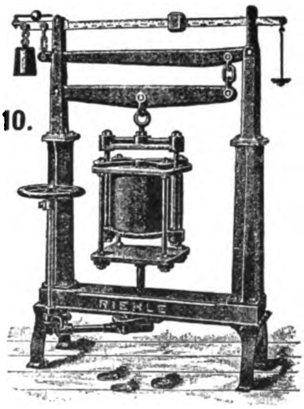
8.



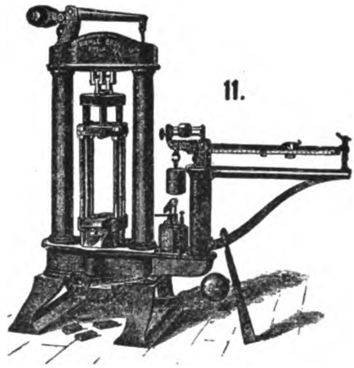
9.



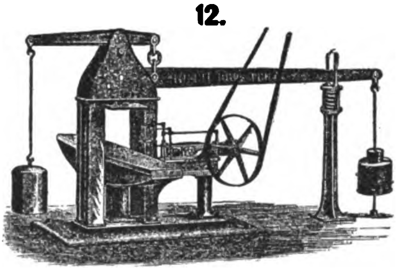
10.



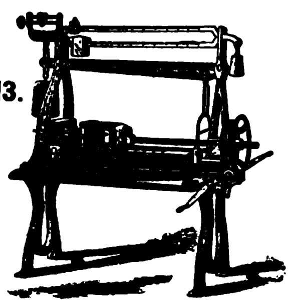
11.



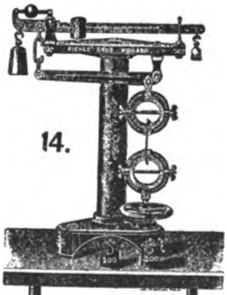
12.



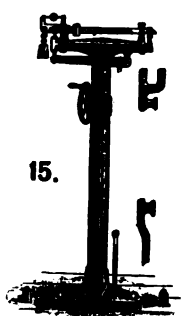
13.



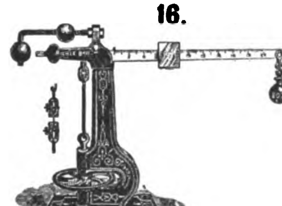
14.

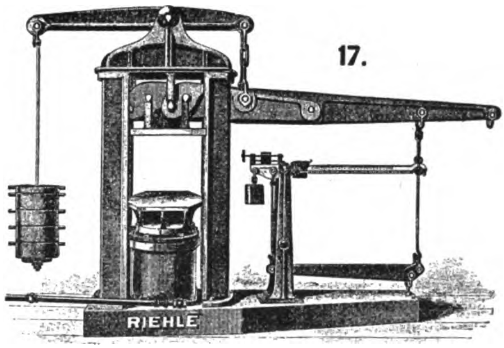


15.

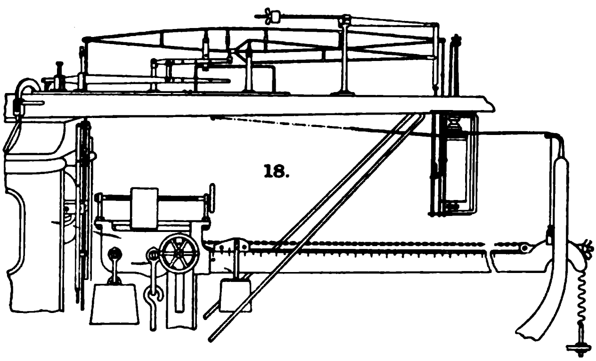


16.

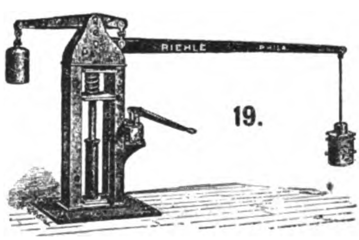




17.

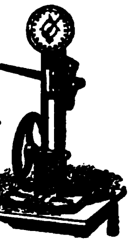


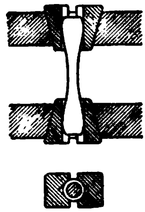
18.



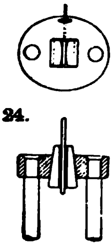
19.

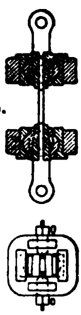
20.

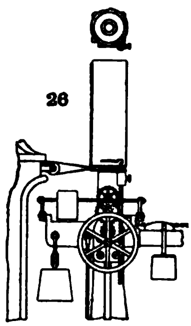
21.


22.


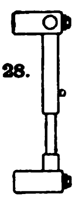
23.

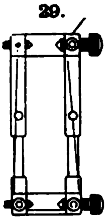

24.


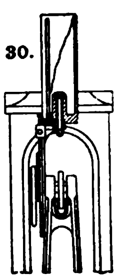
25.


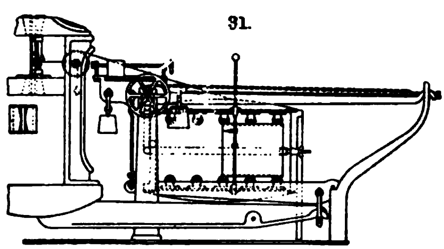
26


27


28.


29.


30.


31.


EXPLANATIONS. Plate 20.

OLSEN TESTING-MACHINES AND APPARATUS. KEEP'S IMPACT MACHINE.

BUILT BY TINIUS OLSEN & CO., PHILADELPHI, PA., U. S. A.

Sects. 640–643. 486 and 525. (*L 102, 113, 51*, 1879. p. 36; 1883, p. 39.)

1, 2. 100-ton Machine; designs.

3-5. Automatic and Autographic Machine.

6-13. Details of this Machine.

14, 15. Similar Machines, for Short and Long Test-pieces; built:

Like Fig.	14	14	15	15
L =	200 t.	150 t.	100 t.	50 t.
S =	12 ft.×11 ft.×5 ft. 4	11 ft. 4×10 ft. 6×4 ft. 8	8 ft. 9×7 ft.×4 ft. 5	7 ft. 9×5 ft. 8×3 ft. 2

16-19. Machines Operated by Hand or Power, No. 16 Arranged for Determining Stress.

Like Fig.	16	17	16 and 17	18
L =	100 t.	30 t.	25	20
S =				4 ft. 8 × 4 ft. 2 × 2 ft. 4
T. P. =				
Like Fig.	18	19	19	19
L =	15	10	7½	5
S =	4 ft. 4 × 3 ft. 10 × 2 ft.	4 ft. × 3 ft. 6 × 1 ft. 9	3 ft. 6 × 3 ft. × 1 ft 6	3 ft. × 2 ft. 10 × 1 ft. 4
T. P. =				

No. 16. Convertible into tension, crushing, and transverse machines, Nos. 18 and 19 do.; especially suitable for instruction; No. 19 largely used in foundries.

20, 21. Wire, Hoop-iron, Horsenail, etc., Testers, for hand and power; built:

Like Fig.	20	20	20	21
L =	10 t.	7½	5	5
S =	4 ft. × 6 ft. × 2 ft.	3 ft. 6 × 5 ft. 6 × 1 ft. 8	3 ft. × 5 ft. × 1 ft. 6	3 ft. 6 × 3 ft. 4 × 11 in.
T.P. =	up to 3 ft. 1.			

22. Cement-testers, for Tension, Crushing, and Transverse-Tests, for hand and power:

Like Fig.	22	22	
L =	1000 lbs.	2000 lbs.	
S =	4 ft. × 5 ft. 6 × 1 ft. 4	4 ft. 6 × 5 ft 10 × 1 ft. 4	

23-25. Machines for Textile Fabrics; built:

Like Fig.	23	24	25
L =	200 lbs.	100 lbs.	20 lbs.
=	10 in. × 2 ft. 9 in. × 8 in.	10 in. × 2 ft. 3 × 8 in.	–

26, 27. Chain-testers; built:

Like Fig.	26	26	26	26	27
L =	200 t.	150 t.	100 t.	50 t.	25 t.
S =	120 ft.	180 ft.	115 ft.	111 ft.	8 ft. 3 × 4 ft. × 3 ft.

28, 29. Spring-testers; built:

Like Fig.	28	28	28
L =	20 t.	30 t.	40 ft.
S =	10 ft. 10 × 6 ft. × 5 ft. 6	12 ft. 6 × 6 ft. 6 × 5 ft. 6	13 ft. 6 × 7 ft. × 5 ft. 6
Like Fig.	28	29	29
L =	50 t.	2500 lbs.	4000 lbs.
S =	14 ft. 6 × 7 ft. 6 × 5 ft. 6	4 ft. 6 × 3 ft. × 2 ft.	5 ft. × 3 ft. 4 × 1 ft. 4

No. 28. For tests under steady and under moving load. No. 29. Tension- and crushing-tests.

30. Transverse Machines for Cast-iron with Deflectometer. Several types.

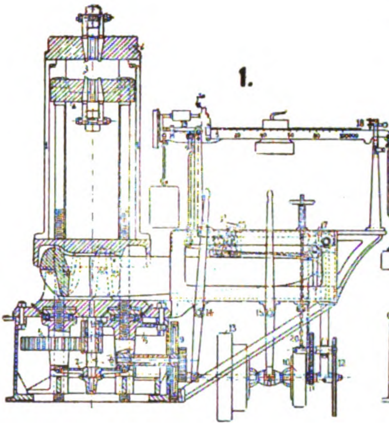
31, 32. Torsion Machine; built:

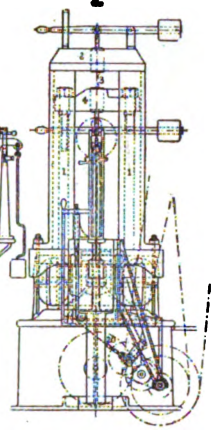
Like Fig.	31	31	31	32
L =	1500 lbs.	5400 lbs.	18000 lbs.	Torsion tool for machine Fig.
S =	18 × 4 × 3 ft.	20 ft. × 4 ft. 4 × 4 ft. 4	22 ft. × 5 ft. × 5 ft. 10	
T. P. =	up to 1½ in. × 16 ft.	2 in. × 16 ft.	3½ in. × 16 ft.	

33. Keep's Impact Pendulum Machine (Heisler Type), for Cast Iron.

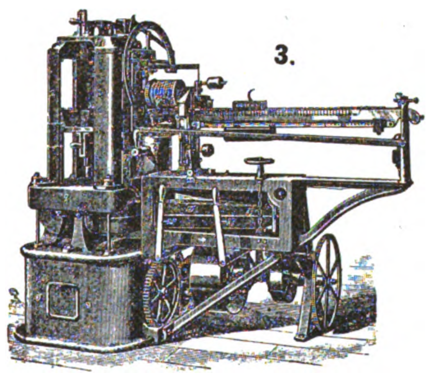
2

1.

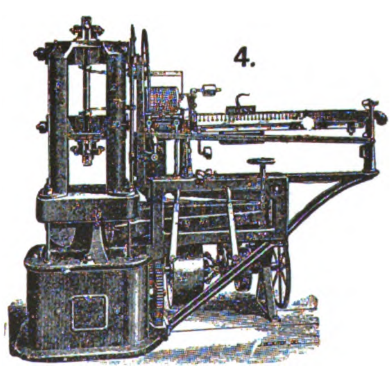


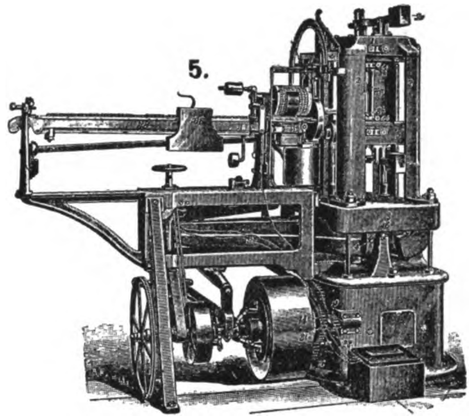


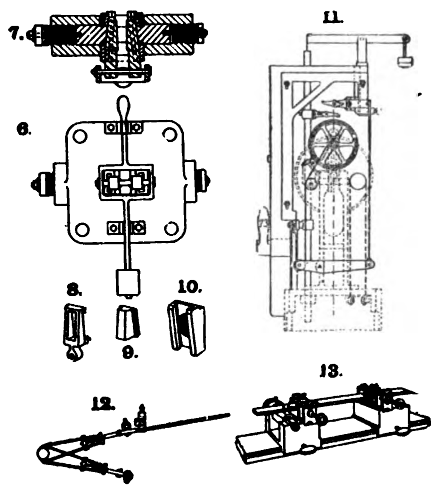
3.

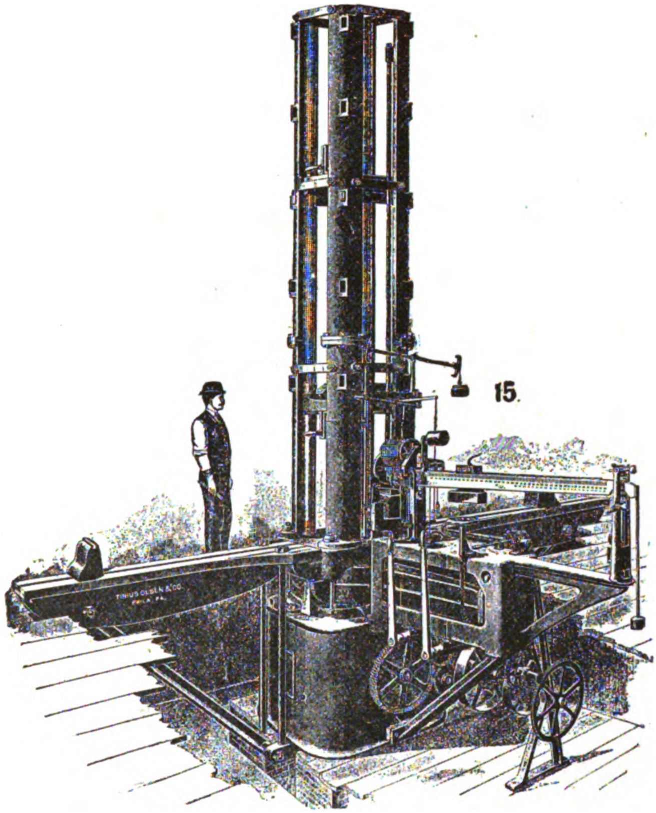


4.

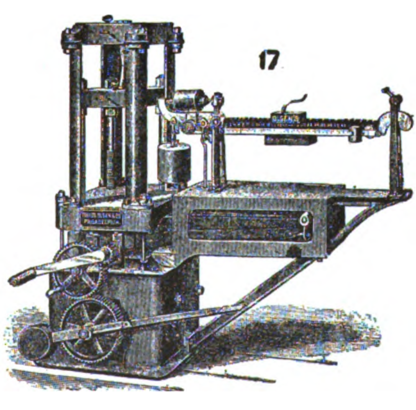



5.

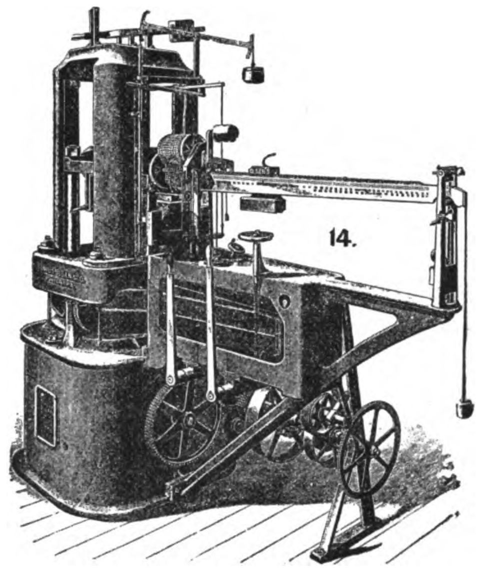

7.
6.
11.
8.
10.
9.
12.
13.



15.

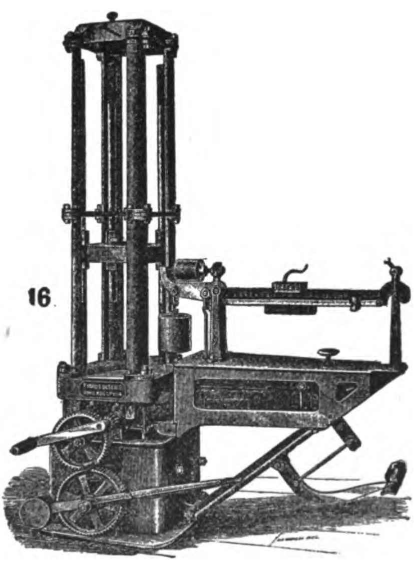


17

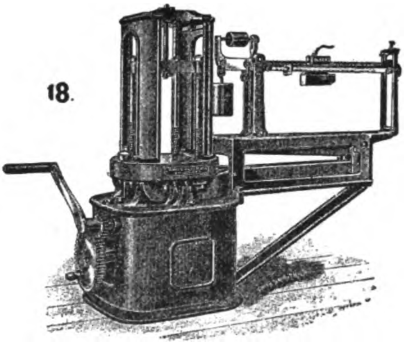


14.

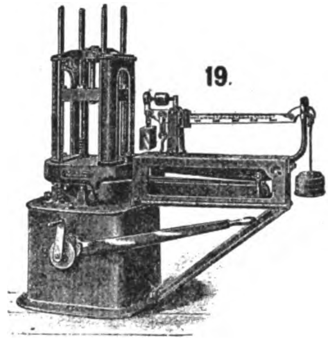
16.



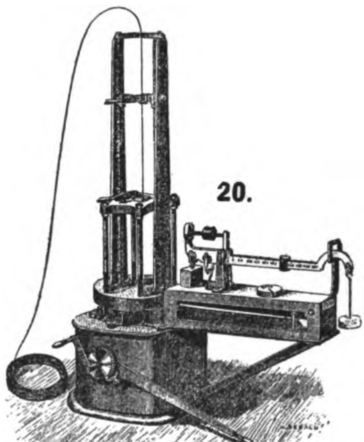
18.



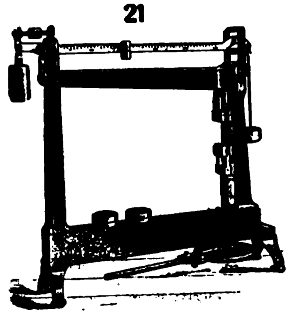
19.



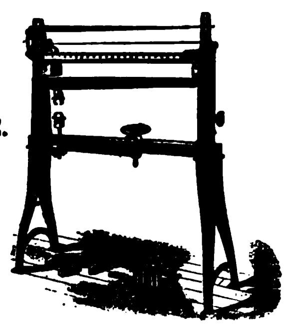
20.



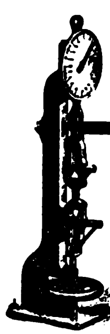
21



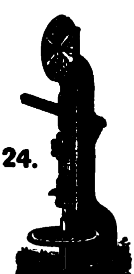
22.

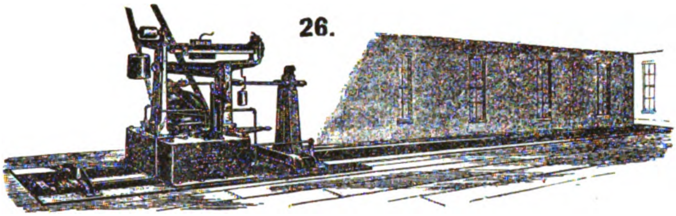


23.

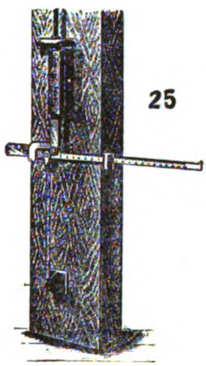


24.

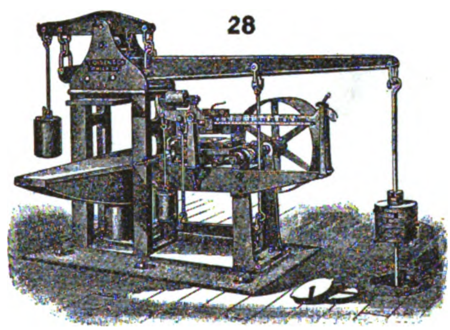




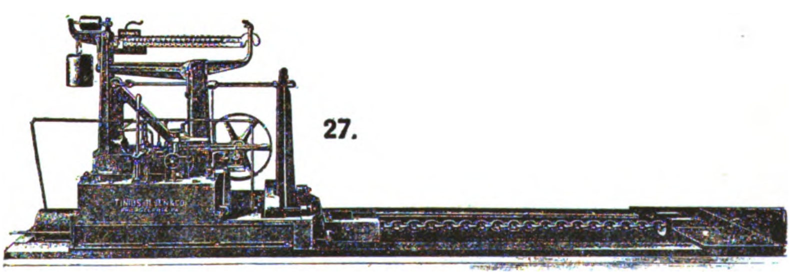
26.



25

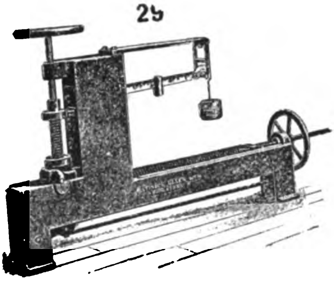


28

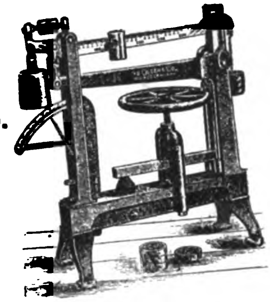


27.

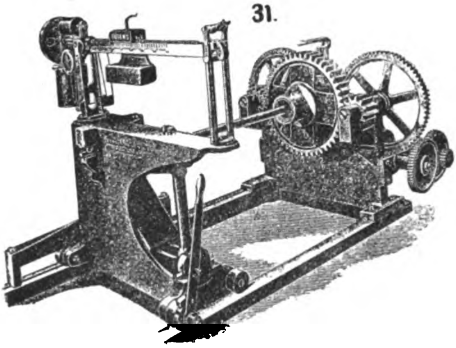
29



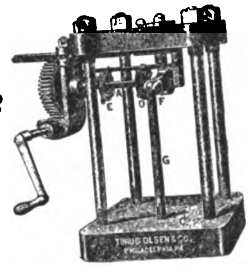
30.



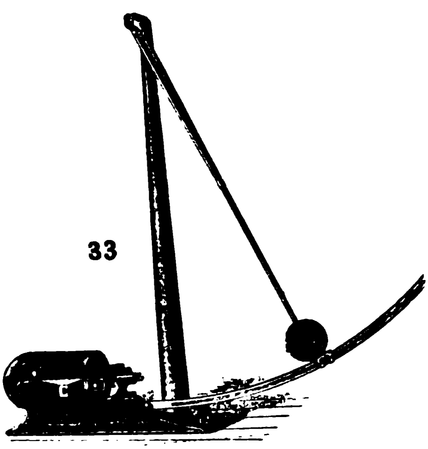
31.

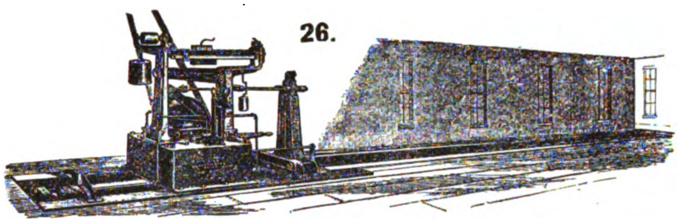


32

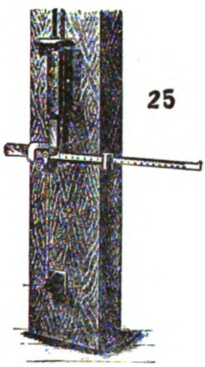


33

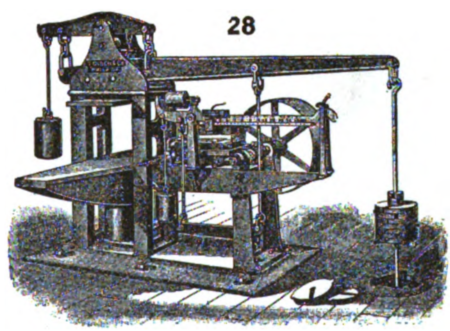




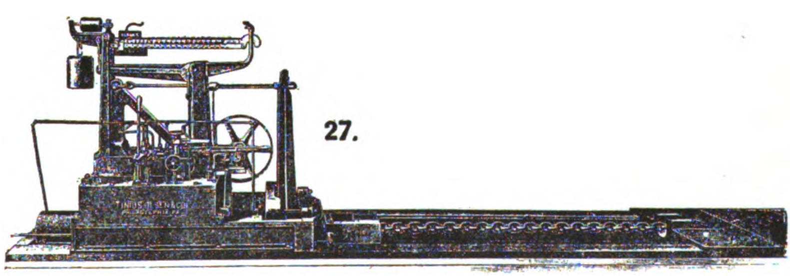
26.



25

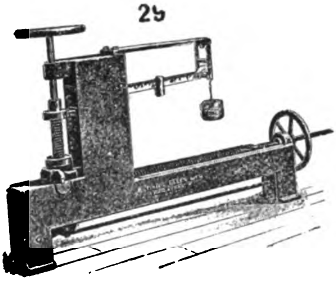


28

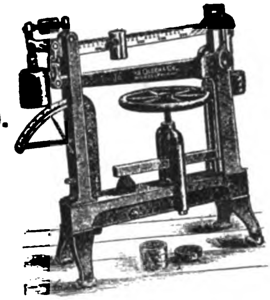


27.

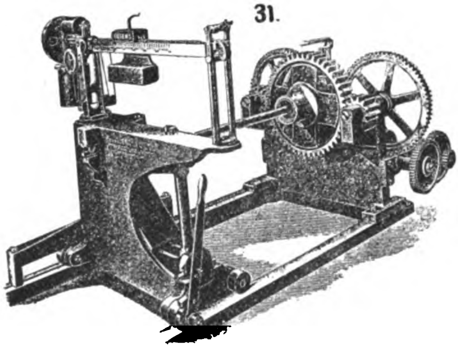
29



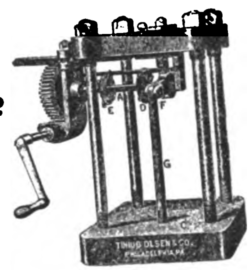
30.



31.



32



33